APPENDIX A

SEA LAUNCH SYSTEM COMPONENTS AND SYSTEM INTEGRATION

A. OVERVIEW

Sea Launch is a new, innovative system for launching commercial satellites from a platform at sea. The Sea Launch program is an international joint venture owned by Boeing Commercial Space Company, RSC Energia, KB Yuzhnoye, and Kværner Maritime a.s.

The system will utilize the proven Block DM-SL and Zenit rocket, manufactured by RSC Energia of Russia and KB Yuzhnoye of the Ukraine, to launch its satellite payloads (spacecraft) from equatorial locations in the Pacific Ocean. The rocket will be launched using two vessels: the assembly and command ship (ACS) and the launch platform (LP), which are provided by Kværner Maritime a.s of Norway. In port, the ACS will serve as the rocket assembly and integration facility and as the mission control center at the launch location. The LP is a converted, semi-submersible drilling platform. It will transport the integrated launch vehicle (ILV) to the launch location and will be used as a steady launch pad for the conduct of launch operations.

The Home Port is proposed as the staging area for Sea Launch operations. It will provide the facilities and personnel necessary to prepare for launch missions. The principal operations to be conducted in the Home Port are spacecraft processing, encapsulation and integration of the spacecraft payload, assembly and checkout of the rocket, vessel maintenance and resupply, and mission operations planning.

The proposed Home Port location for Sea Launch is in Long Beach, California, USA. Sea Launch will lease a portion of the former Long Beach Naval Station from the Port of Long Beach. The 17-acre facility is located on a narrow strip of land, known as the "Navy Mole." This location offers advantages from the perspective of security as well as offering a controlled access location for the conduct of spacecraft fueling operations. From a marine perspective, this location is adjacent to the harbor entrance, offering ready access to the deep water channel, as well as possessing a large turning basin for maneuvering the vessels. Refer to Figure A-1.

Figure A-1. Home Port Location and Vicinity

The integrated rocket and spacecraft to be launched by Sea Launch will be processed in the Home Port according to the following generalized scenario. The processing flow diagram is shown in Figure A-2.

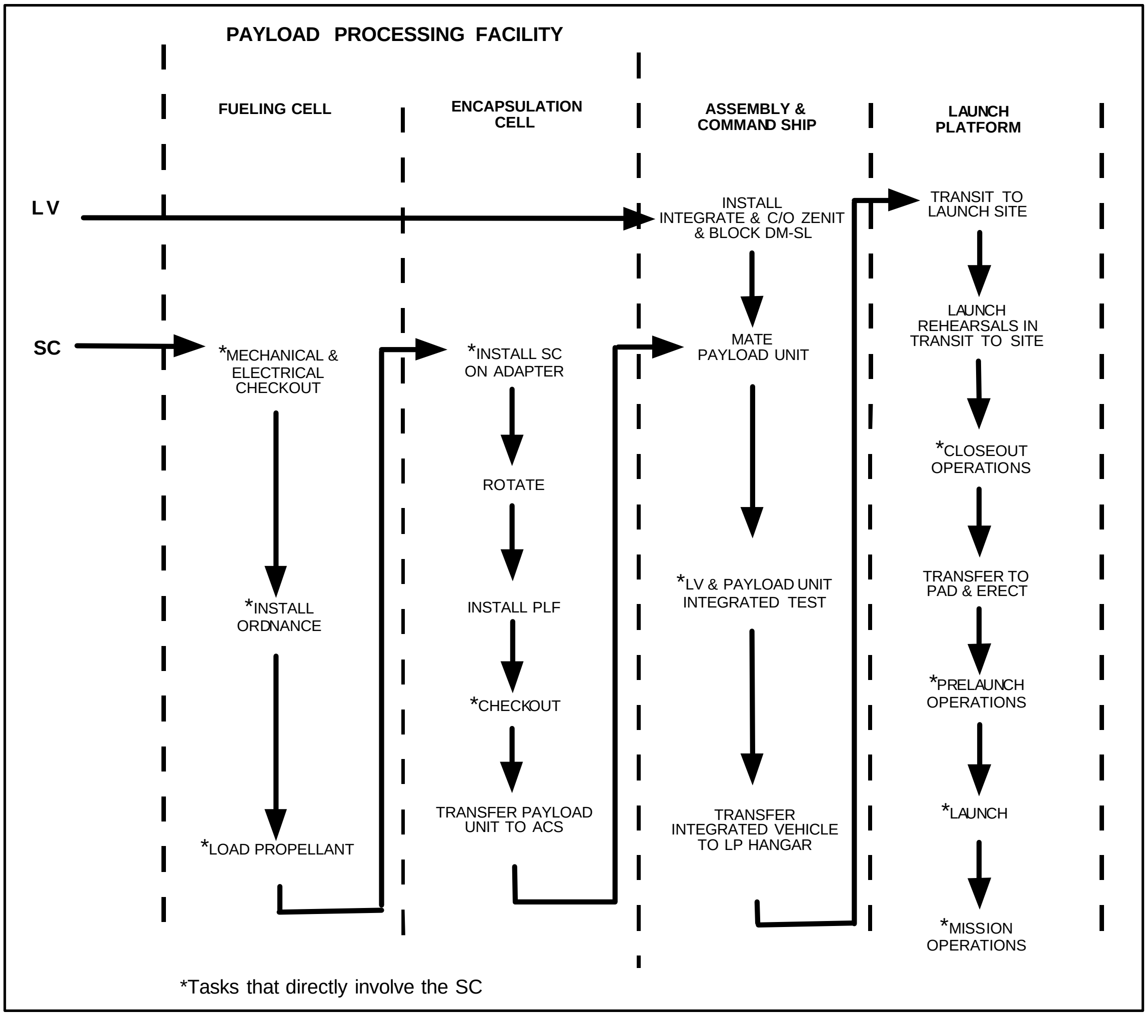


Figure A-2. Spacecraft Processing Flow

1. The spacecraft and its ground support equipment (GSE) will be delivered to the payload processing facility (PPF) by the customer (spacecraft manufacturer). The spacecraft will then be moved to its processing cell and the GSE is set up in the adjacent control room. Processing of the spacecraft will be the final phase of the assembly sequence. Processing will consist of electrical, mechanical and pneumatic functional checks, ordnance installation, and propellant loading.

2. After propellant loading operations are complete, functional tests will be run, the spacecraft will be installed on its adapter, rotated into the horizontal position, encapsulated in the fairing (which has been stored in an on-site warehouse), and tested as required. When encapsulation is complete, the encapsulated payload is considered ready for transfer to the ACS.

3. Individual, inert rocket stages, which are delivered via commercial ships, will be stored at the Home Port. Small solid rocket motors (SRMs), which are used to separate the rocket stages in flight, will be stored separately until they are loaded on the ACS with the rocket stages. Parallel to spacecraft processing, the three inert stages of the rocket will be transferred from the warehouse to the ACS where they will be processed and mated together. During the processing, the upper stage (Block DM-SL) will be partially fueled prior to mating to the second stage. Once the rocket processing, assembly and checkout have been completed on the ACS, the encapsulated payload will be transferred to the ACS for integration with the rocket.

4. On the ACS, the encapsulated payload will be mated to the rocket and the interfaces checked out and verified. When the launch vehicle checks are complete, the ACS and LP will be positioned end to end and the integrated rocket will be transferred from the ACS to the LP. Prior to leaving the Home Port, rocket fuel components and compressed gasses will be delivered and transferred onto the LP. (Note: Fueling of the rocket occurs at the launch location just prior to launch.)
5. Both vessels will depart the Home Port for the equatorial launch region and conduct of launch operations.
6. After launch, the vessels will return to the Home Port. In preparation for the next user, the spacecraft GSE will be removed from the processing facilities, ACS, and LP.

The Home Port facilities will consist of an office building, a payload processing facility, warehouse buildings, and the pier. Each of these areas is described briefly below, and in more detail in Section A.4.

1. The office building is a two-story structure of approximately 2,230 m^2 which currently exists on the location. It contains offices, conference rooms, and a marketing, training, and break area. This will serve as the Home Port management and engineering area in addition to customer offices.
2. The PPF will be a new building constructed approximately 94.5 m east of the existing buildings in the Home Port complex. The building will be approximately 3,000 m^2 with a high bay height of 19.8 m for the encapsulation cell. This facility will be used for spacecraft processing and short-term (less than 30 days) storage of spacecraft propellants. This facility will consist of two processing cells, an encapsulation cell, control rooms, change rooms, fuel cart storage areas, and a central air lock. All spacecraft processing areas will be constructed to Federal Standard 209 Class 100,000 cleanliness standards.
3. The warehouse facilities consist of existing buildings which are located near the office complex, with a total area of approximately 9,290 m^2. The large warehouse building (building 4, Figure A.4-1) will be used for storing inert rocket stages, fairings, and adapters. The remainder of the buildings will be used for storage of spares and consumables necessary for Home Port operations, spacecraft customer spares, and shipping containers. Modifications (e.g., installing doors and shelving) and cosmetic maintenance will be required.
4. The pier is an existing structure adjacent to the other facilities. It is a concrete structure supported by wooden pilings and is capable of supporting any loads which can be transported over highways. It is approximately 335 m by 18.3 m and is accessible from both sides for moorage of the vessels. Water depth at the pier is 10.7 m to 11.6 m, which is capable of supporting SLLP vessels. The pier is equipped with facilities for electrical power, water, sewage, and moorage fittings. Minor modifications to the waterfront adjacent to the pier will be required to provide a ramp landing capable of roll-on/roll-off loading of inert rocket stages and encapsulated payloads to the ACS.

A.1 LAUNCH VEHICLE DESCRIPTION

A.1.1 Vehicle History

The Zenit-3SL is a liquid propellant, launch vehicle system capable of transporting spacecraft to a variety of orbits. Figure A.1.1-1 shows the Zenit-3SL principal components.

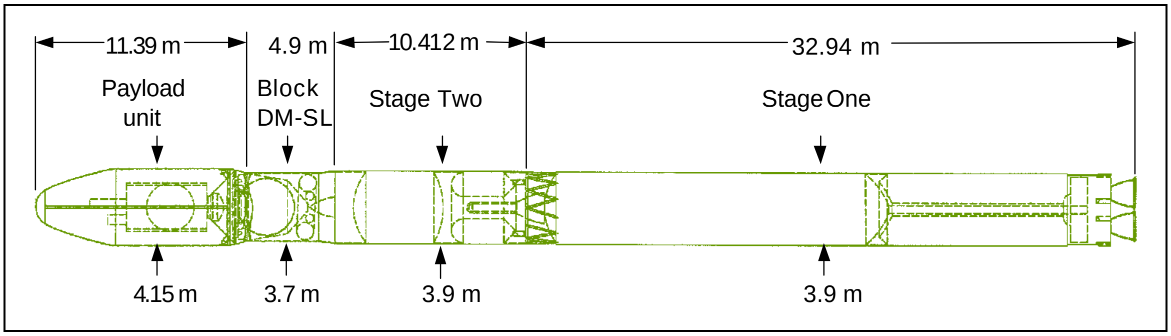


Figure A.1.1-1. Zenit-3SL Launch Vehicle

The first two stages of the Zenit-3SL are manufactured by KB Yuzhnoye in the Ukraine. The basic two-stage Zenit was developed to provide a means of quickly reconstituting military satellite constellations with design emphasis on robustness, ease of operation, and fast reaction times. The result is a highly automated launch system requiring only a small launch crew. First flown in 1985 from the Baikonur Cosmodrome in Kazakhstan, the Zenit's original use was as a launcher for electronic intelligence satellites. As of May 1997, the Zenit has completed 24 missions in 28 launch attempts. All of the Zenit launch vehicle failures resulted in catastrophic events which manifested themselves in engine malfunctions. In each case, the cause of engine failure was identified and remedied through a combination of both process and design improvements. The fourth failure, which occurred in the spring of 1997, is presently being investigated for the final cause and any remedial action required. Additionally, Stage 1 of the Zenit is virtually identical to the strap-on boosters used with the RSC Energia heavy lift launch vehicle. Four strap-ons are used for each Energia launch.

The Block DM-SL constitutes the upper stage of the Zenit-3SL. The Block DM is built by RSC Energia in Russia, and has had a long and successful history as the fourth stage of the Proton launch vehicle. The Block DM superseded the Block D upper stage in 1974. As of May 1997, the Block DM has completed 162 missions in 167 attempts. All five of the Block DM failures resulted from various malfunctions in the propulsion and avionics systems. In each case, full investigations were performed which led to remedial improvements in manufacturing and inspection processes.

A.1.2   Zenit Stage 1

The Stage 1 principal structure is aluminum with integrally machined stiffeners. The RD-171 engine that powers Stage 1 burns liquid oxygen (LOX) and kerosene (RG-1). The LOX tank is positioned above the kerosene tank, and the lower dome of the LOX tank is located in the concave top of the kerosene tank. A single turbopump feeds four thrust chambers, and four differentially-gimbaled thrust nozzles provide directional control during Stage 1 powered flight. Stage 1/Stage 2 separation is accomplished through the use of forward firing solid propellant thrusters located in the aft end of the first stage.

A.1.3   Zenit Stage 2

The second stage of the Zenit also employs integrally stiffened aluminum construction. Stage 2 propellants are LOX and kerosene, and the lower kerosene tank is toroid shaped and the LOX tank is a domed cylinder. This stage is powered by a single nozzle RD-120 engine.

Three-axis control is provided by a RD-8 vernier engine which is mounted in the aft end of Stage 2. The RD-8 uses the same propellants as the RD-120, with one turbopump feeding four gimballing thrusters. The RD-8 produces 8100 kg of thrust. Stage 2/Block DM-SL separation is accomplished through the use of forward firing solid propellant thrusters located near the aft end of the second stage. Stage 1 and Stage 2 of the Zenit configuration are shown in Figure A.1.3-1.

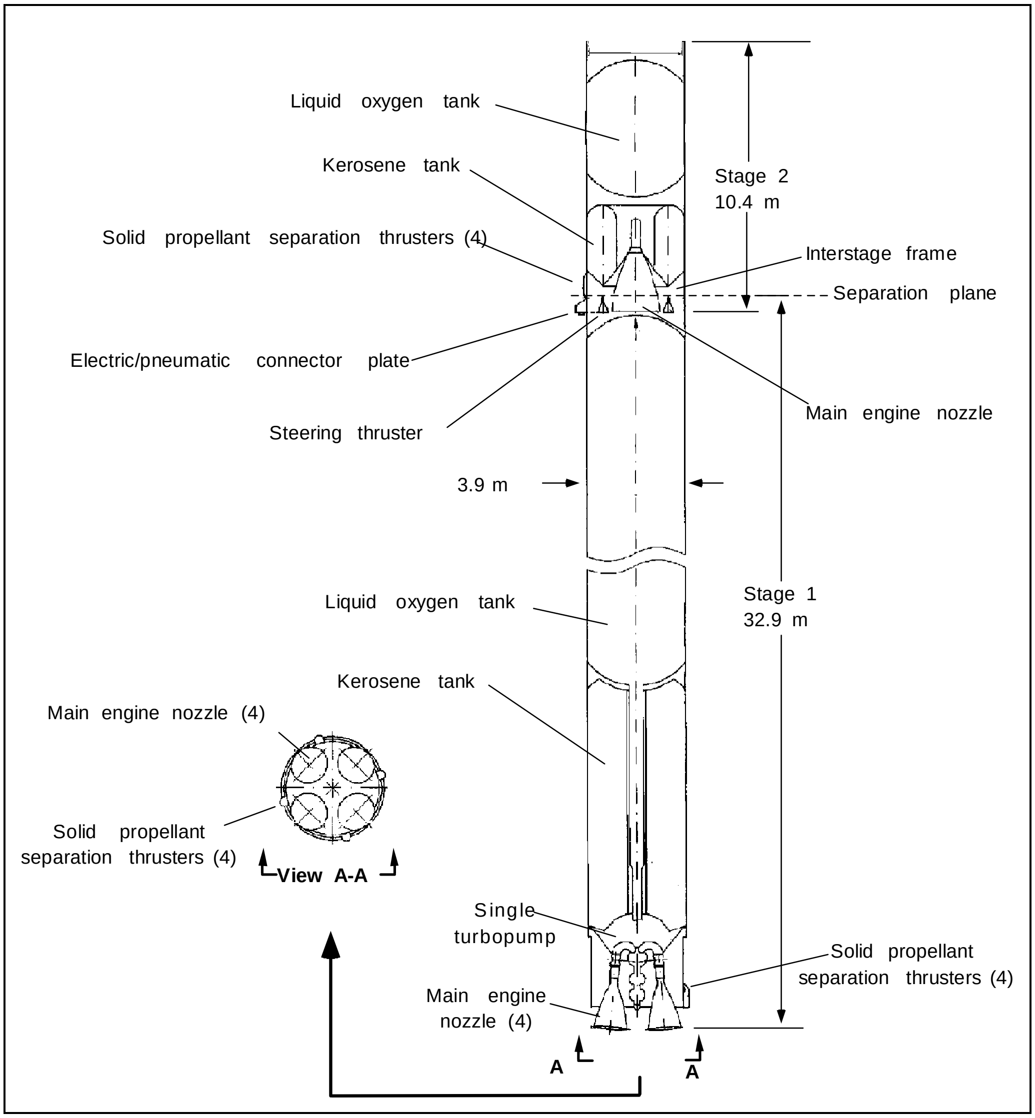


Figure A.1.3-1. Zenit Stage 1 and Stage 2 Configuration

A.1.4 Block DM-SL - Upper Stage

The Sea Launch Block DM-SL (Figure A.1.4-1) is a restartable upper stage which is capable of restarting up to seven times during a mission. The Block DM-SL is enclosed in an interstage cylinder of aluminum skin and stringer construction. All but the upper section of the interstage is jettisoned prior to the first firing of the Block DM-SL main engine. Avionics are housed in a toroidal equipment bay at the front end of the Block DM-SL.

Propulsive capability for the upper stage is provided by the 11D58M engine which operates on LOX and kerosene. The kerosene is contained in a toroidal tank which encircles the main engine turbopump. The spherical LOX tank is located above the kerosene tank. The 11D58M has a single gimballing nozzle which provides directional control during propulsive phases.

Three-axis stabilization of the Block DM-SL during coast periods is provided by two attitude control/ullage engines. Each engine has five nozzles that are grouped in clusters on either side of the main engine nozzle. The attitude control system uses the hypergolic propellants nitrogen tetroxide (N_2O_4) and hydrazine. Unsymmetrical dimethylhydrazine (UDMH) or monomethylhydrazine (MMH) may be used in the Block DM-SL.

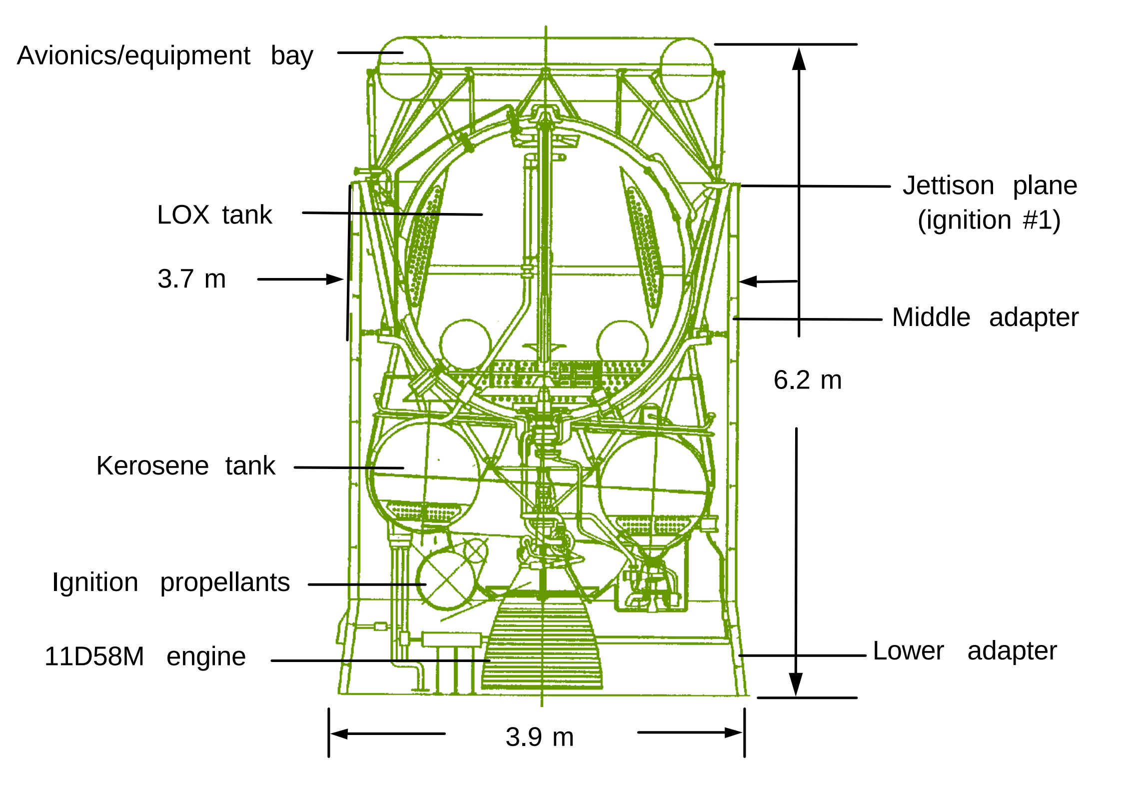


Figure A.1.4-1. Block DM-SL

A.1.5 Payload Unit

The payload unit (PU) consists of the spacecraft, adapter with spacecraft separation system, interface skirt, payload fairing (PLF), and the flight instrumentation package. The PLF, payload adapter (PLA), interface skirt, and spacecraft form a single, transportable item during ground processing (fig. A.1.5-1). These elements are brought together at the payload processing facility (PPF) in the Home Port and are integrated with the launch vehicle as a package onboard the ACS. The PU interface skirt mates to the interfacing ring of the Block DM-SL and encloses its toroidal equipment bay. The PU is 11.39 m long, as measured from the tip of the nose cap to the interface skirt/upper stage interface. The PU has an internal diameter of 3.9 m and an external diameter of 4.15 m.

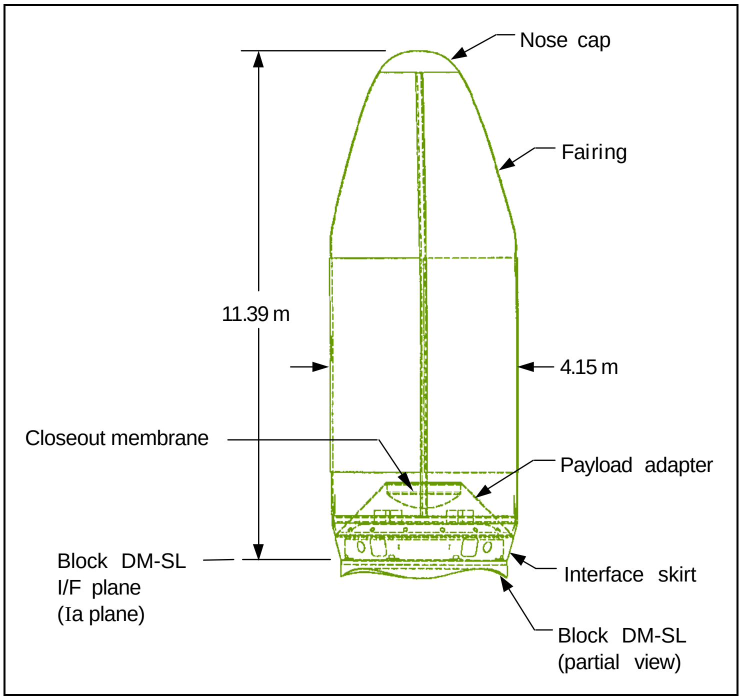


Figure A.1.5-1. Zenit-3SL Payload Unit

A.1.5.1 Payload Fairings

Sea Launch PLFs provide environmental protection for the spacecraft from the time of encapsulation through launch and ascent and can accommodate a wide range of payloads.

The PLF is 10.58 m long and is constructed in two sections of graphite composite external and internal skins. The PLF has a honeycomb core with a metallic nose cap device.

Prior to roll out to the launch pad, access to the spacecraft is gained through the access hatches in the payload fairing. The baseline design includes two PLF access hatches, approximately 0.61 m in diameter, located on opposite sides of the PLF longitudinal separation plane and at least 17^0 from the separation plane. Within PLF structural constraints, variations in the number, location, and size of the hatches can be altered.

Prior to launch, conditioned air is provided to the payload fairing volume. The cooling air flows from the forward end of the PLF to the aft end where it exits through one-way valves on the payload structure.

External thermal insulation protects the PLF structure and limits the interior PLF surfaces from reaching temperatures above 65^0C during ascent. The PLF is jettisoned at a time sufficient to ensure that the spacecraft's dispersed maximum free molecular heating (FMH) never exceeds 1,135 W/m^2. The time of PLF jettison (and associated maximum FMH) can be tailored by the customer.

A.1.5.2 Interface Skirt/Payload Structure

The interface skirt/payload structure, which joins the PLF and adapter to the upper stage, is constructed of aluminum with integral stiffeners. The interface skirt portion is 0.81 m long and accommodates the transition from a 3.715 m diameter on the Block DM-SL to a 4.15 m diameter on the PLF. The payload structure portion provides the structural tie between the spacecraft adapter and the interface skirt portion. The interface skirt/payload structure assembly includes an encapsulation membrane and acts as a contamination barrier between the PU and the Block DM-SL. One-way valves in the adapter structure permit airflow out of the PLF while maintaining positive differential air flow (or pressure differential) in the PLF during all operations.

A.1.5.3 Adapters

The spacecraft adapter, payload structure, and the interface skirt serve as the interface between the spacecraft and the launch vehicle. They physically support the spacecraft in a horizontal attitude for integration with the launch vehicle, during transportation to the launch location, and in a vertical attitude while on the launch pad.

The adapter mechanical interface to the spacecraft is either a bolted or a Marmon clamp design. Spacecraft separation from the adapter is accomplished with separation ordnance or through the release of this clamp.

A.2 MARINE SYSTEMS

The marine segment of the Sea Launch system includes the ACS and the LP, which together will support the integration of the launch vehicle, transportation to the launch location, and launch.

A.2.1 Assembly and Command Ship

The ACS will perform four functions for Sea Launch operations:

1. It will serve as the facility for assembly, processing, and checkout of the launch vehicle.
2. It will house the mission control center, which monitors and controls all operations at the launch location.
3. It will act as the base for tracking the initial ascent of the launch vehicle.
4. It will provide accommodations for the marine and launch crews during transit to and from the launch location.

A first aid clinic will be provided on both the ACS and LP with capability of functioning as a casualty support location in the event of a serious accident.

The ACS (Figure A.2.1-1) is designed and constructed specifically to suit the unique requirements of Sea Launch operations. The basic structure of the ACS is based on a Roll-On/Roll-Off (Ro-Ro) cargo vessel. The ship has an overall length of approximately 200 m and a beam of 32.26 m. Its overall displacement is approximately 30,830 metric tonnes.

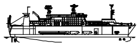


Figure A.2.1-1. Assembly & Command Ship

A.2.2 Launch Vehicle Integration Area

Launch vehicle stages will be loaded onboard the ACS in the Home Port through the stern ramp (Figure A.2.2-1). Processing and assembly of the stages will be conducted on the rail systems in the rocket assembly compartment on the main deck, accommodating parallel processing of up to three launch vehicles at one time. A special area in the bow of the main deck will be dedicated for processing and fueling of the Block DM-SL upper stage. Processing and assembly of the launch vehicle will typically done in port in parallel with spacecraft processing operations, but many of these operations may also be accomplished during transit to and from the launch location.

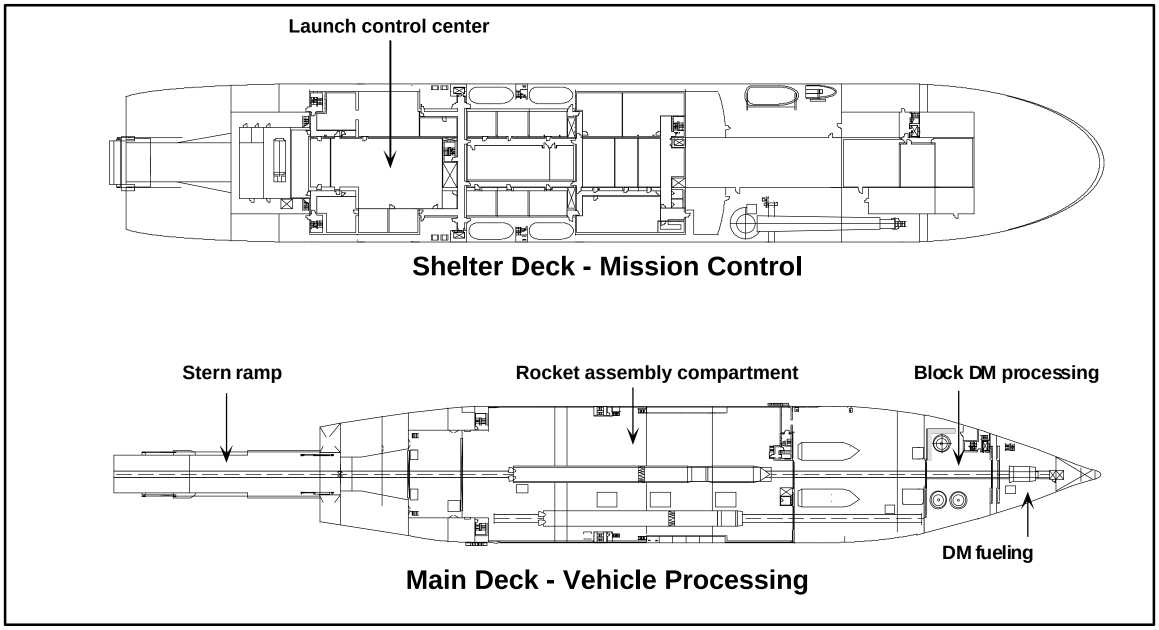


Figure A.2.2-1. Launch Vehicle Processing and Mission Control

A.2.2.1 Block DM-SL Fueling Process

Fueling of the upper stage will be accomplished onboard the ACS prior to mating with the first and second stages. This operation will be accomplished with the ship moored parallel to the pier which will also allow for easy personnel access. Normal ship evaluations and some limited launch support operations will continue during the upper stage fueling operation. The systems supporting this operation will be installed in four compartments located below the shelter deck between frames 221 and 189 (Figure A.2.2-1).

The upper stage fueling compartment (DM fueling) will be located on the main deck between frames 221 and 203. An air lock is provided directly aft of this compartment (frames 203 to 201) to isolate this space from the adjacent assembly areas. Access to the DM fueling compartment will be provided by a large set of sliding doors in the bulkheads at frames 203 and 201 to allow movement of the upper stage through the air lock. These doors will be provided with gas tight seals to maintain the air lock seal. A personnel access door will be provided through the air lock bulkhead on the port side, outboard of the lift/stairwell. This door will also be provided with gas tight seals. The air lock will cover the complete bulkhead between the main deck and the shelter deck. Stuffing tubes and related seals will be provided for all penetrations through the air lock bulkheads. The DM fueling compartment will contain facilities to connect the fuel transfer lines to the upper stage fuel fitting.

Fuel equipment compartments will be provided between the tank top and the main deck between frames 213 and 189. The two compartments directly under the main deck (tween deck) will contain the fuel service system for the two hypergolic components: UDMH and N_2O_4. The two compartments will provide complete separation of the fueling components. A change room will be located forward of each compartment, which will also serve as an air lock between the fuel equipment compartments and the companion way/stair well.

A separate ventilation system, designed to control the potential accidental release of toxic and explosive vapors during fueling operations, will be provided. The supply and exhaust ventilation systems will be balanced to maintain a lower atmospheric pressure in the hazardous areas. The design of a means of scrubbing hazardous vapors from the exhaust air will be developed to achieve zero release of UDMH or N_2O_4. The exhaust from this system will be located near the top of the forward mast, approximately 13 m above the weather deck. This location will also provide additional dilution if any release were to escape.

A.2.2.2 Rocket Assembly Process

Assembly of the integrated launch vehicle includes assembly of the Zenit Stages 1 and 2 and their mating, mating of the Block DM-SL upper stage to the second stage of the Zenit, and mating of the payload unit to the Block DM-SL upper stage.

The Zenit stages will be prepared for assembly by removing protective covers and fixtures used for transportation/shipping and positioned on the center rail in the rocket assembly compartment (Figure A.2.2-1). The first and second stages will be properly aligned and mechanically mated; electrical and piping connections will then be mated and verified. The onboard control system will be tested through the use of a computer-controlled test system. The test software will be verified in the factory prior to use onboard the ACS. Electrical test equipment will use unique connectors to preclude improper connections. Pneumatic test equipment connections will also be of unique configurations. The propellant tanks and piping (liquid oxygen: 1.8 kgf/cm^2) and kerosene tanks (1st stage - 1.6 kgf/cm^2 and 2nd stage 1.5 kgf/cm^2) will be leak tested. The pressurant system's nitrogen and helium tanks are charged to 220 (+10/-5) kgf/cm^2 and the propellant control and flow systems are leak tested at 15 kgf/cm^2. The four retro rockets (stage separation SRMs) will be installed on each stage. The Block DM-SL upper stage will be mated to the assembled Zenit stages and electrical interface connectors will be verified.

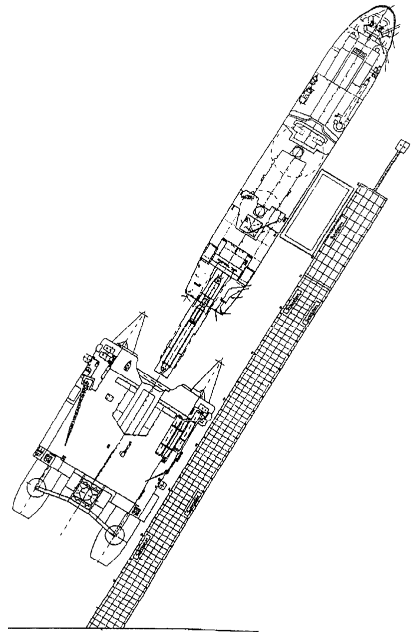
The encapsulated payload will be loaded onto the ACS from land through the stern ramp. Once onboard, the encapsulated payload and its transportation dolly will be positioned on the center rail in the rocket assembly compartment for integration with the launch vehicle. The payload unit will be mated to the Block DM-SL and interface electrical connections will be verified.

After the payload is integrated with the launch vehicle and all checkouts are complete, the integrated launch vehicle will be transferred to the launch platform. Environmental conditioning and monitoring of the encapsulated spacecraft is continuous from spacecraft encapsulation through launch. The only breaks are during transfer from stationary to mobile environmental conditioning units (less than three minites). Monitoring equipment will be mounted near the conditioned air exhaust from the spacecraft and upper stage.

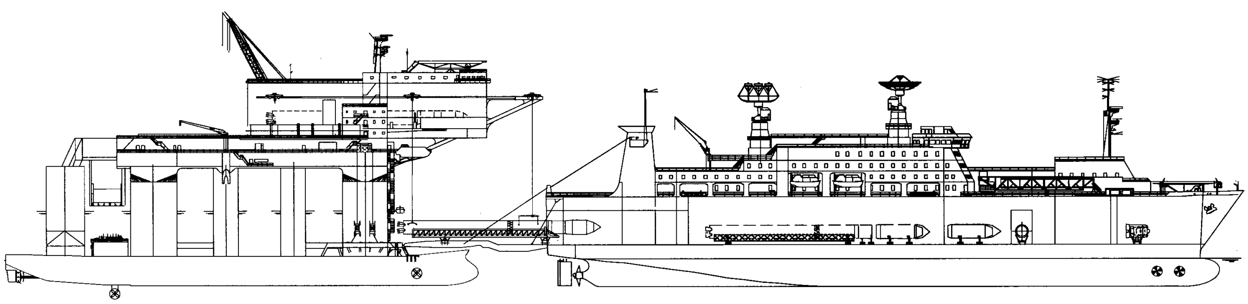
A.2.2.3 Integrated Launch Vehicle Transfer from ACS to LP

Transfer of the ILV from the ACS assembly area to the LP hangar will be accomplished just prior to the LP departing the Home Port for the launch area. At this time, all other operations related to provisioning the LP and preparation of the ILV will have been completed. The following general sequence of operations will be accomplished to achieve the safe transfer:

1. The ACS will be moved from its portside berth and moored by its starboard side forward of the LP so both the ACS and LP centerlines are in a common straight line. The launch platform lies close to the pier, while the ACS has to be moored at some distance from the pier in order to be in centerline with the LP (Figure A.2.2-2).
2. The stern ramp will be lowered in horizontal position and a support cable system is attached between the end of the ramp and the LP. This support cable transfers some load from the ACS to the LP during the operation as well as supporting the stern ramp (Figure A.2.2-3).
3. Door and deck hatches in the front of the LP hangar will be opened and secured in the open position. The two LP hangar cranes will be moved into position to lift the ILV. Four guide cables will be installed (two on each side) between the ramp and the LP crane bridge. The guide cables will be kept taut by a tensioning system and will be used to guide and stabilize the ILV during hoisting.
4. The ILV and carriage will be moved out onto the ramp and positioned for lift. The ILV lifting equipment will be mounted on the rocket and prepared for connection to the LP crane hooks. The carriage prelift hydraulic system cylinders will now be prepared to lift the ILV from the carriage.
5. The ILV lifting equipment includes transverse bars that will be attached to the crane hook. The ends will be equipped with rollers that attach to the guide cables and also to the hydraulic prelifting system. The transverse bars will be prepared for connection to the lifting crane hooks.
6. Both crane hooks will be lowered and connected to the lifting bars. Slack will be taken out of the crane lifting cables but no tension is applied at this time.
7. Hydraulic power will be applied to the prelifting cylinders and the ILV is lifted clear of the carriage to a predetermined height. Slack will be taken out of the crane lifting cables but no tension will be applied at this time.
8. Final checks for the lift operations will be accomplished. These include weather, the mooring arrangement, personnel on station, and ensuring that no other vessels are in positions which can lead to disturbances.
9. The ILV load will be transferred to the crane by lowering the prelifting cylinders.
10. The ILV will then be hoisted by the cranes, which operate simultaneously to keep the rocket in a horizontal position, up to the level required to move it into the hangar. Once the ILV is at this level, the lifting bars will be released from the guiding rollers and the guide wires.
11. The ILV will then be moved into the hangar position to be landed on the erector carriage.
12. The erector wagon will be moved into position under the ILV and the load will be lowered on to the erector carriage.
13. The ILV lifting equipment will be moved back to the carriage on the ACS stern ramp and the carriage will be moved into the assembly area.
14. The stern ramp will be released from the LP and both vessels will be readied for departure.



Plan View



Side View

Figure A.2.2-2. ACS and LP Mooring Arrangement During Integrated Launch Vehicle Transfer

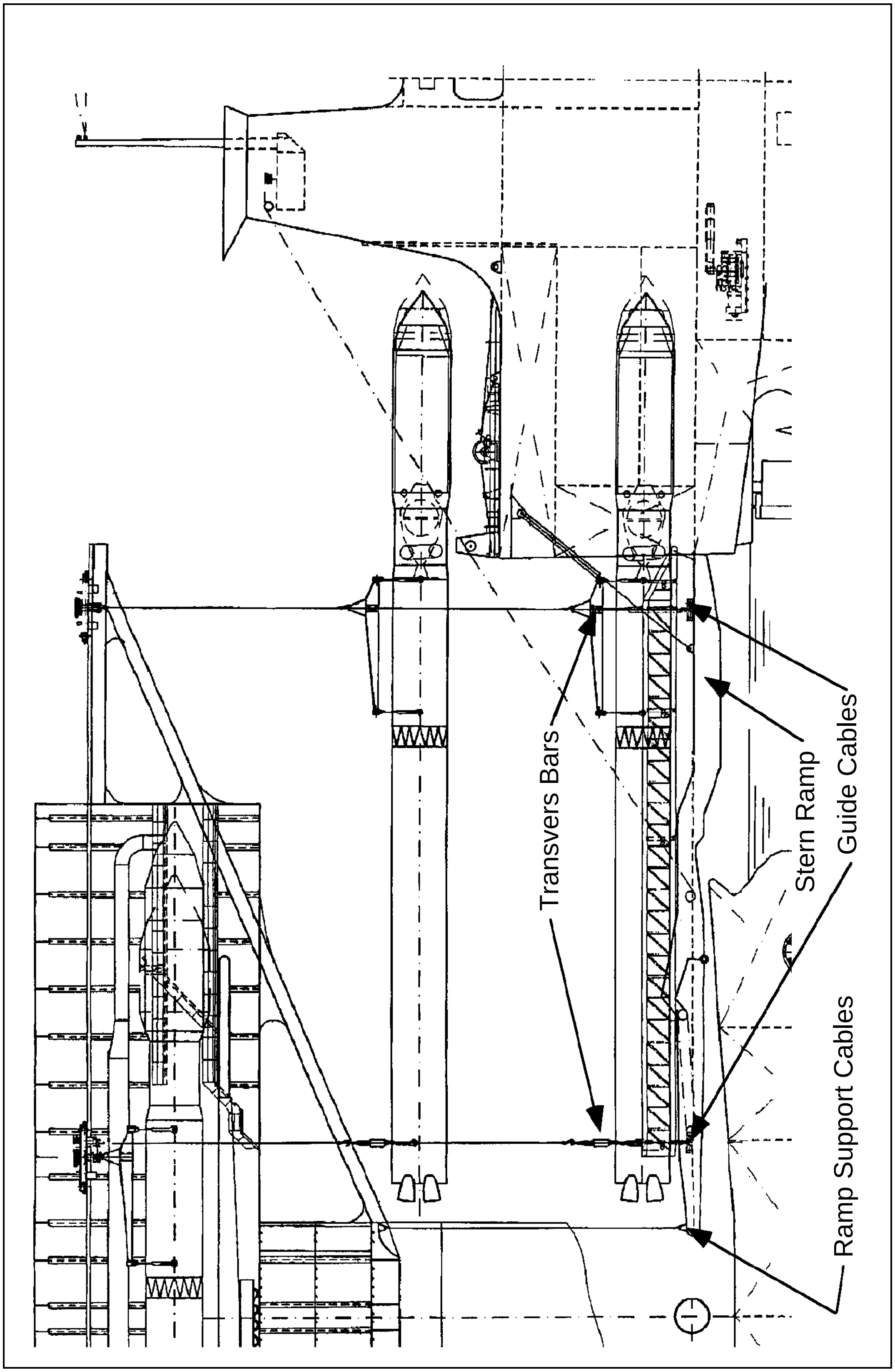


Figure A.2.2-3. Integrated Launch Vehicle Transfer Arrangement (1 of 2)

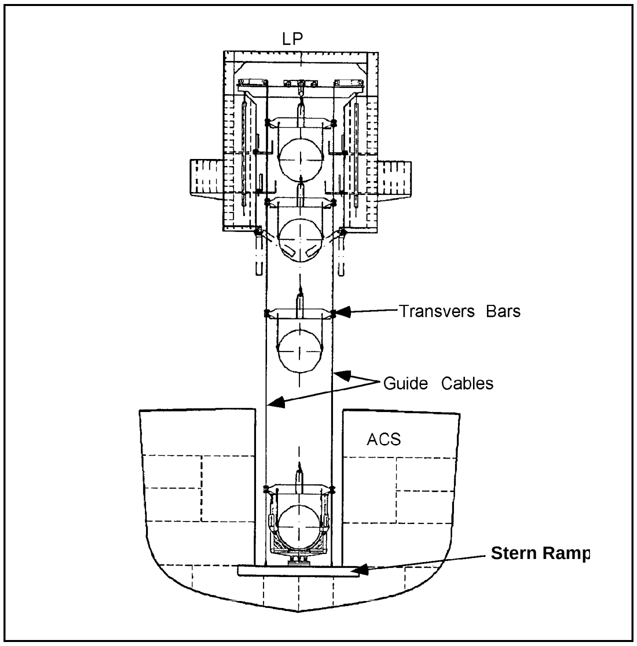


Figure A.2.2-3. Integrated Launch Vehicle Transfer Arrangement (2 of 2)

A.2.3 Launch Platform

The LP will serve as the transport vessel for the integrated launch vehicle and also serve as the launch pad. It will also provide accommodations for the marine and prelaunch crews during transit to and from the launch location. It will have all the necessary systems for launch vehicle erection, fueling, and for the conduct of launch operations.

The LP (Figure A.2.3-1) is a modification of an existing semi-submersible oil platform. This platform was designed for continuous operations in the extreme environment of the North Sea. In the relatively benign environment at the Sea Launch locations, this design will provide an extremely stable platform from which to conduct launch operations. The LP will be self-propelled by diesel-electric motors and will ride catamaran style on a pair of large pontoons. Once at the launch location, the pontoons will be submerged by ballasting to achieve the stable launch position, level to within approximately one degree. The LP will have an overall length (at the pontoons) of approximately 133 m and the launch deck will be 78 m by 66.8 m. Its overall transit displacement will be approximately 27,400 metric tonnes. Once transferred to the LP in the Home Port, the integrated launch vehicle will ride to the launch location in the enclosed hangar on the main deck. After LP ballasting at the launch location, the rocket will be rolled out to the launch pad and erected in preparation for launch.

After the launch vehicle has been erected and all launch system checks are complete, the crew members will be transferred to the ACS. Vessel station keeping and launch operations will be conducted from the ACS via redundant RF links.

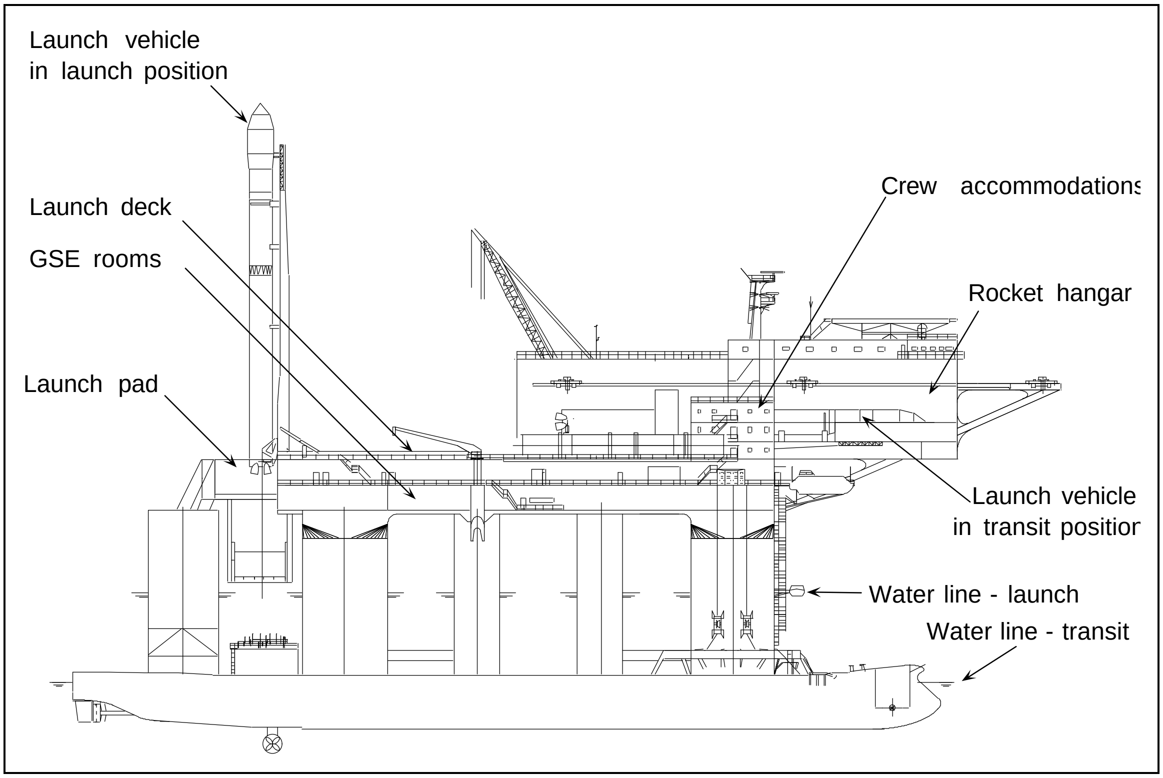


Figure A.2.3-1. Launch Platform

A.2.4 Transit Operations

The integrated launch vehicle, including the encapsulated payload, will be supported on the transporter/erector in the LP hangar during transit to the launch location. Accommodations for six customer technicians will be provided onboard the LP during transit.

While the ACS and LP are in route to the launch location, a mission rehearsal will be conducted. The rehearsal involves the launch personnel and customer personnel onboard the ACS, the tracking assets (Selena-M tracking ship, Altair satellite [sometimes called Luch satellite], ground stations, etc.), and the customer's spacecraft control center. The rehearsal will simulate the prelaunch operations and post launch operations up through spacecraft separation and completion of the Block DM-SL's contamination and collision avoidance maneuver (CCAM). The launch vehicle operations on the LP will be simulated while the launch vehicle remains in the hangar. Successful completion of the launch rehearsal is a prerequisite to launch. These operations are simulated to a major extent and systems that could pose a threat to the environment are not exercised.

Transit of the two vessels between the Home Port and the launch area will be a normal maritime operation and is controlled by existing regulations as noted in Section 3 and in Appendix B.

A.2.5 Platform Launch Operations

At the launch location, the LP will be lowered from the transit draft to the launch draft, and the ACS and LP will moor alongside each other. The launch draft provides a more stable platform. The launch may be accomplished in mean significant wave heights up to 2.5 m. This launch position will be accomplished at least 17 hrs before scheduled launch time (T). A connecting bridge will be extended between the two vessels to allow prelaunch processing personnel access to the LP. Final spacecraft "hands-on" operations (i.e., ordnance arming) will be accomplished and payload fairing hatches will be closed out. Launch management personnel and the customer will be polled and approval will be given to roll out the integrated launch vehicle (ILV) from the hangar to the launch pad.

The hangar hatches will be opened and the automatic sequence that moves the Zenit-3SL to the launch pad will be initiated. As the launch vehicle moves to the pad, the electrical, pneumatic, hydraulic, and propellant lines will be automatically connected. At the launch pad the launch vehicle will be rotated to a vertical position. Prior to rotation, the portable conditioned air supply will be switched to the launch pad conditioned air supply system.

At this time, the majority of the LP and launch support personnel will leave the LP and the ACS maneuvers to a position approximately five km from the LP. The repositioning of the ACS will occur at approximately T-15 hrs.

The transfer and verification of launch systems control and LP systems control will be started. Initial purging and conditioning of launch vehicle fueling systems will be started and final preparations accomplished. When the transfer of control and the prelaunch checkouts are completed and the results have been verified, the remaining LP and launch support personnel will be transferred by motor launch to the ACS prior to rocket fueling. The LP will now be uninhabited and all critical systems will be controlled remotely from the ACS. The transfer of the remaining personnel to the ACS will occur between approximately T-5 hrs and T-3 hrs.

The fueling of the Zenit (LOX and kerosene) and LOX loading of the Block DM-SL will be started at approximately T-2.5 hrs and completed at T-24 min. The erector will be lowered to the horizontal position and moved into the hangar and the hatch doors will be closed. Fuel lines will be drained and purged with GN_2 prior to disconnecting.

Final launch sequence will be accomplished. In order to minimize exhaust effects on the LP and acoustic effects on the spacecraft, a freshwater deluge system will be used in the flame deflector. The water deluge to the flame trench/deflector will begin at T-5 sec. Stage 1 ignition will occur at T-3 sec. The main command to ramp up the main engines to launch thrust will be issued at T=0 after engine parameters have been verified by the onboard control system.

The Zenit-3SL will be held in place on the launch table by hold-down clamps at the base of the first stage. These clamps will be released after the computers confirm that the Stage 1 engine is operating properly and engine ramp up exceed 50% thrust.

If the engine parameter verification or the hold-down clamps release is not successful, the engine will be shut down by the onboard control system prior to lift off.

A.3 ABORT OPERATIONS

Launch abort operations are described in Section 4.3 as part of the environmental assessment , and they are further addressed as a part of mission definition in the license application submitted to AST (SLLP, 1996a). In general, a launch abort is a controlled event in which the rocket would be stabilized and fuels extracted and stored for reuse. The launch vehicle would then be lowered to a horizontal position and moved into the hanger on the LP. The situation would then be assessed before a decision can be made to restart the launch sequence or return to the Home Port.

A.4 HOME PORT FACILITIES AND SERVICES

The Sea Launch Home Port complex will provide the facilities, equipment, supplies, personnel, and procedures necessary to receive, transport, process, test, and integrate the spacecraft and its associated support equipment with the launch system. It also will serve as the home base for launch operations with facilities to support and service the Sea Launch vessels, including office and storage facilities. There will be no provision to support major ship repair. This work will be accomplished at a commercial facility.

The proposed Home Port is located in southern California in the Port of Long Beach. This site is part of the former Long Beach Naval Station located on the southern side of Terminal Island within the Long Beach harbor district. The proposed Home Port is located at the east end of the "Navy Mole" (Figure A.4-1), which is a large breakwater forming the western and southern boundaries of Long Beach Harbor. Access to the site is via I-110 or I-710 off the San Diego freeway (I-405). Long Beach airport (21 km), Los Angeles airport (40 km), and Orange County airport (38 km) are all within close proximity.

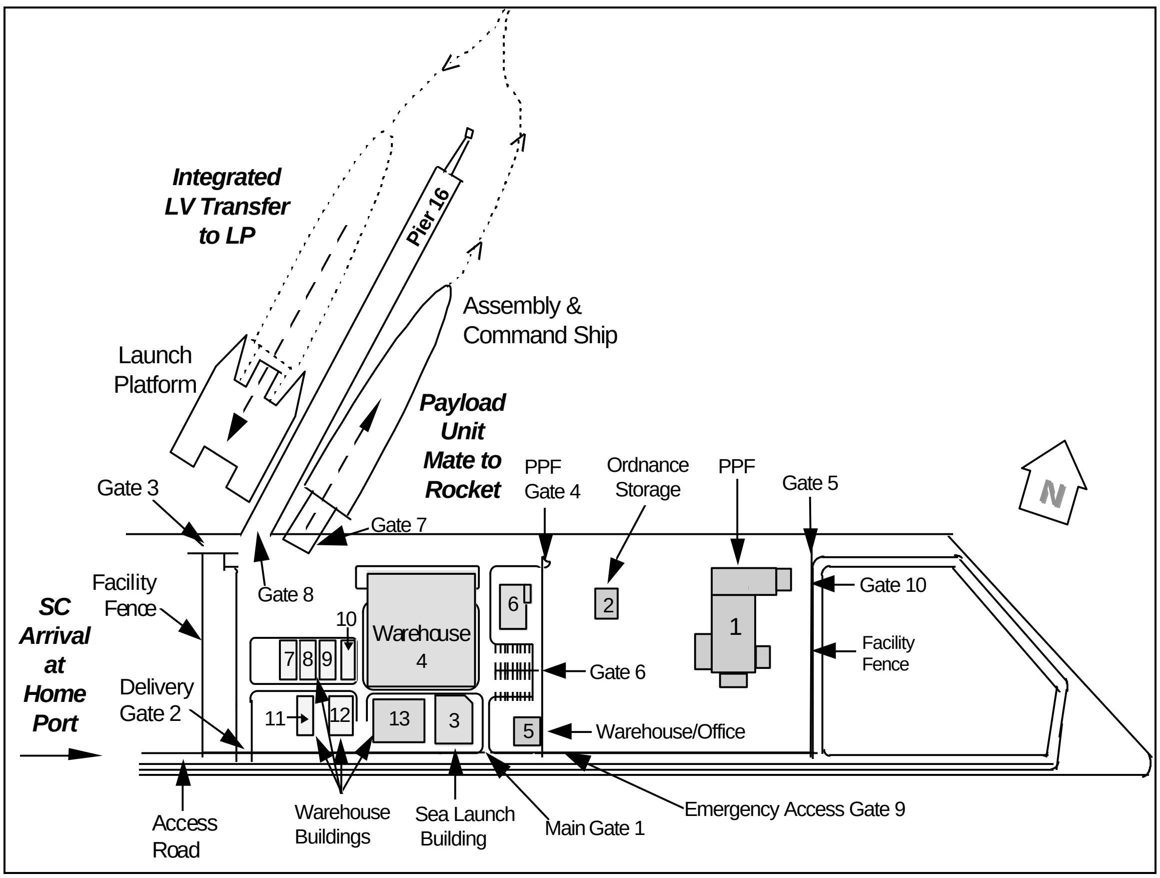


Figure A.4-1. Sea Launch Home Port Complex

The Home Port complex will consist of a payload processing facility (PPF), Sea Launch and customer office facilities, several warehouse buildings, and a pier. The complex is bounded by the access road to the south and the harbor to the north. A security fence encloses the property with access through three gates in the south side fence. The main entrance is through Gate 1, which is staffed 24-hours, seven days a week. Gates 2 and 3 allow oversize truck access to the pier and PPF respectively, and are normally locked. An interior fence separates the PPF area from the rest of the complex, and access to this area is controlled through Gate 4. Two additional emergency access gates, Gate 5 and Gate 6, are located at the northeast and northwest corners of the facility.

Water, sewage, and gas service will be provided to the site by local utility companies. Commercial electrical power will be supplied by Southern California Edison. This power will be distributed through transformers, panel boards, and circuit breakers to all areas within the complex. Emergency power for the PPF will be provided through a 500 kW backup generator with an automatic switching system. To provide further limited protection during test periods, an uninterruptible power supply (UPS) will be available in the processing area.

Industrial waste generated during program procession will be processed in accordance with existing state and federal regulations.

A.4.1 Spacecraft Processing Operations

After delivery to the Home Port, electrical and mechanical checkout of the spacecraft will be conducted in the PPF. After stand-alone testing, the spacecraft will be placed on a customer-provided fueling stand. The customer will be required to perform all required ordnance installation operations prior to fueling. Initial mass properties can be determined at this time. After the customer’s fueling team propellant loading operations are complete, final mass properties determinations will be conducted.

While the customer conducts spacecraft ordnance and fueling operations, Sea Launch personnel will transfer the payload fairing and adapter from storage to the PPF encapsulation cell and prepare them for installation. When spacecraft processing is complete, the spacecraft will be transferred to the encapsulation cell and mounted vertically on the flight adapter. The adapter and spacecraft will then be rotated to a horizontal position to accommodate the installation of the payload fairing. Communication checks will be conducted on the spacecraft. Conditioned air flow will be initiated and the payload unit (consisting of the spacecraft, adapter, fairing, and upper stage interface skirt) will be transported to the ACS as a single unit. Spacecraft and equipment environments will be monitored throughout the entire process.

Once onboard the ACS, the payload unit will be mechanically and electrically mated to the previously assembled and tested rocket. Integration tests will be performed between the PU and the rocket. Upon the completion of testing, the integrated launch vehicle (ILV) will be transferred onto the LP and stowed in the LP hangar. The ACS and the LP will then depart for the launch location.

A.4.2 Payload Processing Facility

The PPF (Figure A.4.2-1) is located in Building 1 on the east side of the Home Port complex (Figure A.4-1). In support of the trend in the industry towards “ship and shoot” spacecraft processing operations, this facility will provide common cells for the conduct of both non-hazardous and hazardous spacecraft operations. All spacecraft processing, propellant transfer operations, pressurization, ordnance preparation, and payload fairing encapsulation operations will be accomplished in the PPF. This area will be separated from the rest of the complex by an interior fence with controlled access through Gate 4 during hazardous spacecraft operations.

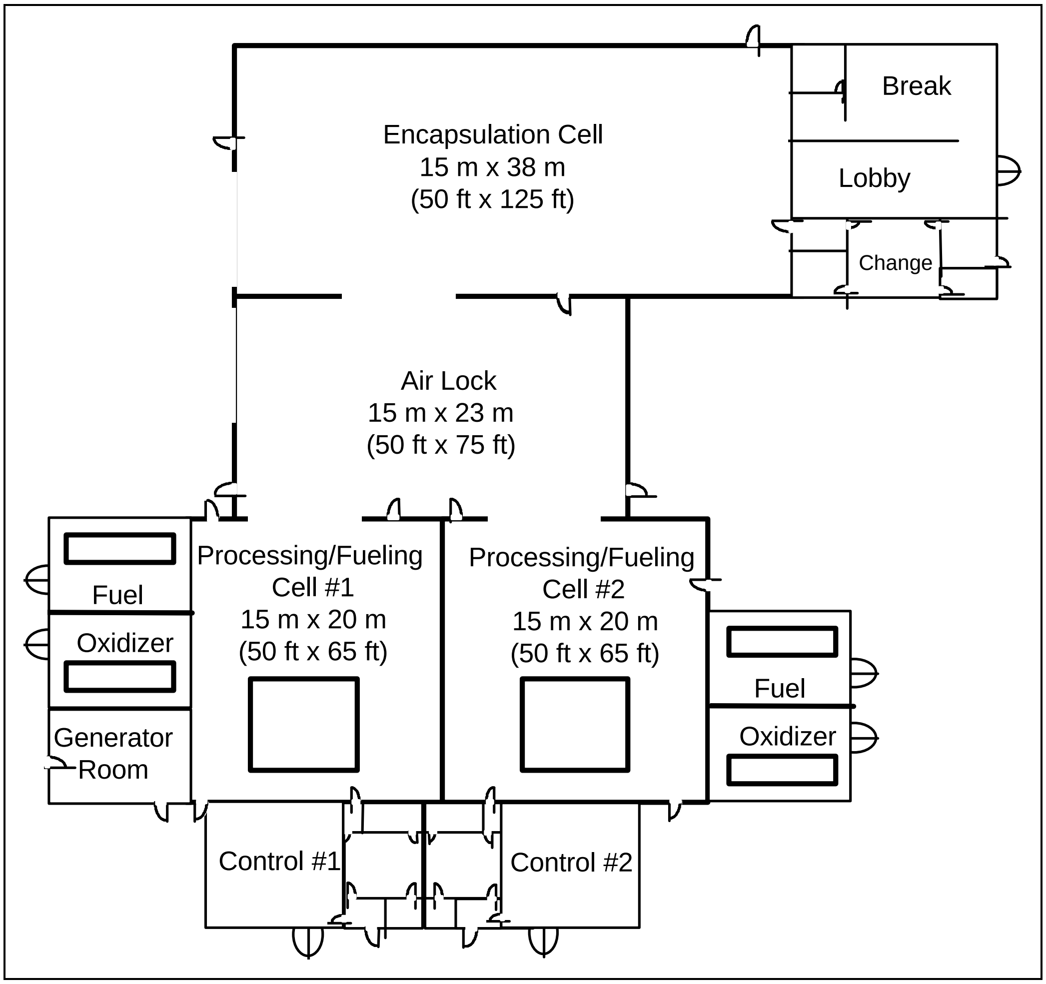


Figure A.4.2-1. Payload Processing Facility

Building 1 will have an overall area of approximately 3,900 m^2, and its major features will include:

1. Processing/fueling cells.
2. Fuel storage rooms.
3. Oxidizer storage rooms.
4. Encapsulation cell.
5. Common air lock.
6. Control rooms.
7. Garment change rooms.
8. Lobby/break area.
9. Generator room.

The processing/fueling cells, encapsulation cell, and air lock are cleanrooms will be maintained to Federal Standard 209 Class 100,000 cleanliness standards. Air filtration will be provided by pre-filters and high efficiency particulate air (HEPA) final filters. To facilitate cleanliness control, the interior wall surface of these areas will be enamel-coated gypsum board and the ceiling surfaces will be vinyl-faced gypsum panels. The floor coverings will be electrically static dissipative and will be compatible with either wheeled dollies or air bearing pallets. Temperature in the air lock, processing/fueling cells, and encapsulation cell will be maintained to 21°C ±3°C. Relative humidity will be maintained between 35%

and 60%. Card readers on personnel doors to high bays and control rooms will provide for controlled access.

A.4.2.1 Processing/Fueling Cells

The PPF will provide two separate, high bay processing/fueling cells configured to support spacecraft processing operations. In order to support spacecraft fueling operations, each cell is equipped with a 7.6 m by 7.6 m fueling island in its center. This island will be surrounded by a covered trench which will drain to one of two dedicated 18,192 L fiberglass, reinforced polypropylene tanks for emergency spill containment. To maintain cleanroom standards, access to each high bay will be controlled via a garment change room. Each processing/fueling cell will be equipped with the following features:

1. Work areas of approximately 300 m^2.
2. Motorized steel rollup access door with manual chain drive backup mechanism. Clear opening measuring 6.1 m by 12.3 m.
3. Personnel access from the air lock through a steel personnel door or from the garment change room through an air shower.
4. Emergency exit only personnel doors along outside walls.
5. Overhead traveling crane with capacity of 13,600 kg with maximum hook height of 15 m.
6. Breathing air system and protective garments for fueling crews.
7. Gas monitoring/detection system for spacecraft fuels.
8. Power receptacles.
9. Potable water hose bibbcock.
10. Vacuum ports with quick disconnect connectors and vacuum line.
11. Closed-circuit television cameras.
12. Wall-mounted telephone.

The two processing and fueling areas will have heating, ventilation, and air-conditioning systems that will provide these areas with an adequate ventilation rating. These areas will be classified Class I, Division 2, up to 3 m above the finished floor. Pits or trenches in the floor will be classified as Class I, Division 2. The areas above 3 m will not be classified in regard to electrical hazard grouping.

Operating personnel will be advised of potential safety concerns through the use of the processing facility public address system, a warning beacon system located on the exterior of the building, and a fire detection and alarm system. The warning beacon system will provide green, amber, and red beacons. The green beacon will be illuminated whenever the building is in a normal state with no fueling operations in progress. Manual switches will activate the amber beacon whenever a potentially hazardous operation is taking place. The red beacon will be activated by the toxic gas monitoring system.

Two single point toxic gas monitors will be provided in the processing, air lock and encapsulation areas, and one single point toxic gas monitor will be provided in each fuel staging cart room. The monitors are capable of monitoring for both components: nitrogen tetroxide (N_2O_4) and monomethylhydrazine (MMH). The alarms will be sounded locally and will also activate the red warning beacon on the exterior of the building. Two alarm set points will be provided; the lower will be set at 75% of the toxic limit, and the higher will be set at 25% of the lower explosive limit (LEL) which will activate the ventilation system purge system for the area. Remote alarm indication will be provided in the main office building.

The payload processing facility fire suppression system will be a dry pre-action system. This system will have compressed air in the lines, maintaining a “dry pipe” condition. The system will be activated by two independent but necessary actions: a smoke/heat detection alarm signal from any of the mounted detectors or from a manual pull station; and an intense heat source sufficient to melt a fusible link in the sprinkler head. The first alarm system action will open a valve which charges the system with water. A high intensity heat source must then be present to melt the fusible plug. This system will provide some protection from water damage to high value hardware in case of a false alarm.

The facility will contain a ground loop system consisting of ground rods and bare copper cable installed around the building. The loop will be tied to every other perimeter building column. A ground buss will be provided in each propellant cart area, each control room, and in the processing and encapsulation areas. Lightning protection per NFPA-78 will be provided.

Access to the facility will be limited to authorized personnel and is controlled by a card reading access control system. The access control system will be a part of the Security Information Management System.

A.4.2.1.1 Propellant Cart Storage Rooms

Two propellant cart storage rooms for each processing and fueling cell will be provided for temporary storage of fuel (MMH) and oxidizer (N_2O_4) carts and associated ground support equipment (GSE). The rooms will have an approximate floor area of 37 m^2 with a clear vertical height of approximately 2.7 m and steel access doors measuring 2.4 m by 2.4 m. Emergency drains to the respective fuel and oxidizer containment tanks (18,168 L) will be provided in each room as well as a gas monitoring/detection system for spacecraft fuels.

A wet scrubber system will be provided for the processing fumes that may be released during the fueling operation or in case of an accident. One scrubber will be provided which can be connected to either containment tank via the vent piping system.

A.4.2.1.2 Propellant Carts/Tanks

Propellants will be delivered from the vendors in tanks approved by the U.S. Department of Transportation (DoT) in accordance with Code of Federal Regulations (CFR) 49, Transportation. Tanks planned for use are DoT 110A500W tanks (maximum 908 L capacity) or DoT 4BW tanks (maximum 454 L capacity). Both types of transport/storage tanks will be used for the direct transfer of propellants into the spacecraft by way of a closed-loop system.

A.4.2.1.3 Summary of Propellant Operating Procedures

The amount of propellant to be loaded will be a function of the spacecraft’s weight, its mission, and altitude. The satellites that will be processed through the payload fueling facility will have a mass ranging from 1,500 kg to 3,500 kg. The propellant weight fraction will be between 50% and 70% of the overall payload mass.

Liquid propellant, N_2O_4 and MMH, will be received and staged (temporary storage) in DoT approved containers (i.e., in accordance with CFR 49). The typical container contains 908 liters of liquid propellant. The propellants will be stored in separate rooms until they are needed to fuel the spacecraft.

The normal load for a spacecraft requires the transfer of propellant from one tank for each fuel component. Normal practice is to have a second tank of each fuel component available as a backup.

When the spacecraft is fueled, one tank of fuel will be moved into the processing cell at a time. Following transfer of that fuel component into the spacecraft tanks, the processing cell will be cleared of all traces of that component prior to handling the next tank. This will maintain complete separation of the two components at all times.

Although the facility will have two processing cells, only one spacecraft will be fueled at any given time. Even in the instances where the operation requires the preparation of two spacecraft for a dual payload launch, the spacecraft will not be fueled simultaneously. Once fueled, the spacecraft will be moved into a separate cell for encapsulation in the payload unit.

A.4.2.2 Encapsulation Cell

An encapsulation cell will be provided in the PPF for the preparation of payload fairings and adapters, payload mating, and encapsulation. To maintain cleanroom standards, access to the encapsulation cell will be controlled via the garment change room and the air lock.

A.4.2.3 Air Lock

An air lock will be located between the encapsulation cell and the payload processing and fueling cells. This air lock will provide an isolated area to establish required cleanliness levels for new equipment arriving prior to being moved into one of the clean processing areas and will allow movement between clean areas.

A.4.2.4 Control Rooms

A control room for contractor GSE will be located adjacent to each processing/fueling cell.

A.4.2.5 Garment Change Rooms

The garment change rooms associated with each processing/fueling cell will provide an area for personnel to don cleanroom garments and fueling suits prior to entering the cells. Each room will have a floor area of approximately 27.9 m^2 and will contain personnel lockers, garment racks, fueling suit storage, cleanroom supply storage, a rest room, and benches. An air shower and a rotary brush shoe cleaner will be located at the entrance to each processing/fueling cell.

A.4.3 Solid Rocket Motor Storage

The ordnance storage in Building 2 (Figure A.4-1) will be located on the east side of the Home Port complex. This building will provide storage for 24 Zenit separation motors and one spacecraft motor. Solid rocket stages include the solid propellant separation motors of the Zenit stages and a solid propellant stage that may be included in some spacecraft.

The solid rocket motor storage building will be a single story, concrete masonry structure with a steel joist roof framing system. Beyond the usual loads required for any building, this facility must also meet the design requirements for the storage of solid propellants prescribed by the Department of Defense (DoD 6055.9 STD), the Uniform Building Code, and the Uniform Fire Code. The motors to be stored in this facility are classified Hazardous Division 1.3 or mass fire hazard. A mass fire hazard is one in which the item will burn vigorously with little or no possibility of extinguishing the fire in storage situations.

Explosions will normally be confined to pressure ruptures of containers and will not produce propagating shock waves or damaging blast over pressures beyond the quantity distance (Q-D) requirements prescribed in DoD (6055.9 STD) and by the Chemical Propulsion Information Agency (CPIA). The building will not be designed as an explosive resistant structure since the primary hazard is mass fire, not an explosion.

A.4.4 Quantity Distance for Home Port Facilities

The determination of Q-D requirements for safe and segregated storage and handling of spacecraft propellants is based on proposed operations and on criteria established by various governmental agencies. The proposed operating procedures used in the analysis are based on the procedures currently used at other U.S. commercial spacecraft processing facilities. The criteria used to determine Q-D requirements are contained mostly in U.S. Department of Defense (DOD) publications, but also include criteria contained in a joint agency document developed by CPIA. The criteria in these manuals were applied to assumptions made by using the procedures currently employed by the spacecraft industry. This resulted in establishing a Q-D of 94.5 m for inhabited buildings and 56.7 m for public traffic routes. For solid propellant stage separation motors stored on site, the required Q-D is 29.3 m for both inhabited buildings and public traffic routes.

Q-D reference documents:

CPIA Publication 394 - “Hazards of Chemical Rockets and Propellants, Volume 1, Safety, Health, and Environment,” dated June 1985.

DoD 6055.9 STD - “DOD Ammunition and Explosives Safety Standard,” dated October 1992.

Establishes storage compatibility groups (SCG) for explosives. These SCGs are used to keep incompatible materials away from each other during storage. Nitrogen Tetroxide (N_2O_4) is a hazard group I (fire hazard); SCG A (initiating explosive) and monomethylhydrazine (MMH) is a hazard group III (fragment hazard); and SCG C (items that upon ignition will explode or detonate).

TM 5-1300 - “Structures to Resist the Effects of Accidental Explosions,” dated November 28, 1990. NAVFAC P-397, AFR88-2.

A.4.5 Warehouse and Storage Facilities

The high bay area in Building 4 (Figure A.4-1) will be used for storage of inert launch vehicle stages and payload fairings.

Building 5 is a small warehouse/office building that will be used to house a small machine shop and contains offices for Sea Launch resident technicians.

Buildings 7, 8, 9, and 10 offer approximately 1,486 m^2 of storage for customer supplies, equipment, and shipping containers. They are constructed of corrugated steel walls and ceilings with slab on grade floors. Each building is approximately 12 m by 30 m with a vertical height of 6.1 m. Access for equipment is through a single door in the end of each building measuring 2.4 m by 3 m. A single steel personnel access door is located on the end of each building measuring 0.9 m by 2 m. The storage buildings do not contain overhead cranes. Equipment loading is accomplished by either forklifts or wheeled dollies.

Buildings 11, 12, and 13 will be used for the storage of Sea Launch equipment and supplies. With prior coordination, additional customer storage may be arranged in these facilities if necessary.

A.4.6 Home Port Administrative Facility

The Sea Launch office in Building 3 (Figure A.4-1) will provide facilities for the resident Home Port administrative and professional staff and customers. It is a two-story structure with an area of approximately 2,230 m^2. It will consist of a marketing area, a training area, offices, conference rooms, and a break area.

A.4.7 Pier Facilities and Fueling Services

The pier provides facilities for moorage, servicing, and resupply of the Sea Launch vessels. It has a concrete surface over pilings and is approximately 335 m by 18.3 m. It has provisions for electrical power, communications, water, and sewer services to the vessels while in port. It will also have equipment for loading fuels, compressed gasses, and cryogens. Mooring provisions will allow securing the vessels to both sides of the pier for rocket integration and vessel provisioning operations. The vessels can also be secured in tandem on the west side of the pier for transfer of the integrated rocket from the ACS to the LP. Encapsulated payloads will be loaded onto the ACS using the stern ramp.

Kerosene and liquid oxygen are the primary propellants for Stage 1 and Stage 2 of the Zenit rocket and the Block DM-SL upper stage. The only primary propellant fuel loaded onto the launch vehicle prior to leaving the Home Port will be a small quantity of kerosene on the Block DM-SL upper stage. The remainder of the kerosene and all the liquid oxygen will be carried in bulk storage tanks on the LP and transferred to the ILV at the launch location.

Liquid oxygen, liquid nitrogen, and pressurized gaseous helium will be commercially procured for delivery to the Home Port pier in the supplier’s mobile equipment. This equipment is designed to meet the applicable requirements for highway transport set by DOT standards in CFR 49. To support their mobile equipment, the supplier may also provide generic equipment that meets appropriate standards.

The following approximate quantity of material will be required for each launch cycle:

Oxygen -	500 metric tonnes
Nitrogen -	240 metric tonnes
Helium -	1 metric tonne
Kerosene (RG-1) -	120 metric tonnes

A.5 ROCKET LAUNCH AND TRACKING OPERATIONS

A.5.1 Zenit Stage 1 and Stage 2 Operations

Zenit first and second stage flight operations are completely automatic. For a typical GTO mission, duration of Stage 1 flight is approximately 2 min and 30 sec, while Stage 2 separates at about 8 min and 41 sec into the mission. A flight event timeline is included in table A.5.1-1.

Table A.5.1-1. Typical Mission Event Times - GTO Mission

Time (min:sec)	Event
00:00	Liftoff
00:08	Begin pitch over
01:04	Maximum dynamic pressure
01:49	Stage 1 begin gradual throttle to 75%
02:09	Stage 1 begin throttle to 50%
02:21	Stage 2 vernier engine ignition
02:23	Stage 1 shutdown command
02:26	Stage 1 separation
02:31	Stage 2 main engine ignition
03:37	Payload fairing jettison
07:09	Stage 2 begin main engine gradual throttle to 85%
07:29	Stage 2 main engine shutdown command
08:44	Stage 2 vernier engine shutdown
08:44	Stage 2 separation
08:49	Block DM-SL middle adapter jettison
08:54	Block DM-SL ignition #1
12:46	Block DM-SL shutdown #1 / LEO park orbit
42:46	Block DM-SL ignition #2
49:02	Block DM-SL shutdown #2/ GTO
49:17	Spacecraft separation

All Stage 1 and Stage 2 events will occur within the view of either the ACS or the Selena-M tracking ship. The spent stages will fall in the Pacific Ocean, well short of the coast of South America and the major coastal shipping lanes. Any deviation of flight trajectory from preprogrammed limits will cause onboard systems to automatically terminate propulsion and end the mission.

At second stage separation from the Block DM-SL, four solid propellant rocket motors at the base of Stage 2 will fire to back the stage away from the Block DM-SL. The pause between Stage 2 shutdown and Block DM-SL first firing will be approximately 10 sec. Half way through this period, the Block DM-SL middle adapter will be jettisoned.

Following Stage 1 engine ignition and liftoff, the aerodynamic loads will be minimized by flying with a near zero angle of attack through the high dynamic pressure (Q) regime. A maximum Q of 5300 kgf/m^2 will occur 65 sec after liftoff. A maximum axial acceleration of four g's will occur at 110 sec. At this point the engine will gradually throttle to 75% over a period of 20 sec and then immediately will throttle to 50%, which it will hold until the engine shutdown command at 143 sec. Stage 1 separation will occur at 145 sec.

The Stage 2 engine will ignite slightly before the Stage 1 engine shutdown command, and the main engine will ignite five seconds after separation. To satisfy spacecraft thermal requirements, the payload fairing will be jettisoned at about 220 sec. At 430 sec, the main engine will gradually throttle to 85% over a period of 20 sec. This will be immediately followed by an engine shutdown command at 450 sec. The vernier engines will continue burning for an additional 75 sec, at which time they will shutdown and Stage 2 separation will occur.

A.5.2 Block DM-SL (Upper Stage) Operations

Prior to launch, the Block DM-SL onboard systems will be turned on and initialized, its oxidizer will be loaded, and power will be transferred from the LP umbilical to the Block DM-SL internal power supply. During Stage 1 and 2 flight phases, the Block DM-SL will remain inactive, except for preparations for autonomous flight. Upon reaching the interim orbit, the Block DM-SL will separate from the launch vehicle. Final insertion to a low earth orbit (LEO) park orbit will be achieved with a single main engine burn at the interim orbit apogee with no change in inclination. Prior to each subsequent main engine firing, the Block DM-SL will perform a settling burn using the attitude control system. Burn program options include, but are not limited to, two- or three-impulse insertion of the spacecraft directly into geosynchronous orbit (GEO), one- or two-impulse insertion into geosynchronous transfer orbit (GTO), and multiple burns (up to a maximum of seven) to medium earth orbit (MEO) or planetary escape. Launches from the equator will take up to eight hours to reach geosynchronous orbit.

Block DM-SL ignition will occur 10 sec after Stage 2 separation. Immediately after separation, the Block DM-SL middle adapter will be jettisoned. The Block DM-SL engine will burn for 230 sec to establish an intermediate LEO park orbit. After a 30 min or more coast in this park orbit, the engine will restart and burn for an additional 375 sec to inject into GTO. The 30 min coast will allow for sufficient engine thermal conditioning at the time of restart, and applies to all Block DM-SL restarts.

The LEO park orbit, combined with the equatorial launch location, may be used to deliver a spacecraft to any GTO apogee longitude in a relatively short period of time. Alternatively, the park orbit may be eliminated so that the Block DM-SL directly injects into GTO with a single 605 sec burn. This option cannot be used to deliver directly to any longitude, but it does complete the mission quickly without a coast phase or engine restart.

The Block DM-SL is capable of performing seven engine restarts and can handle a variety of missions and injection strategies. For example, intermediate and high earth orbit satellites may be delivered to either a transfer orbit or the final orbit. Additionally, the Block DM-SL has the capability to perform the phasing to the final desired location in that orbit. During the intermediate coast phases, the Block DM-SL can accommodate sun-angle pointing and continuous thermal rolls.

Tracking and telemetry return will be provided by the ACS, Selena-M tracking ship (if deployed), Altair communication satellites, and existing Russian-controlled ground stations. During passive flight phases, specific attitude control maneuvers (i.e., a thermal roll) may be conducted by using the attitude control/ullage propulsion engine to meet spacecraft requirements.

Optional functions include establishment of a spin rate of up to 30 rpm prior to spacecraft separation and establishment of a specific orientation at separation. The spacecraft target orbit parameters will be determined and insertion accuracy will be verified for the moment of separation. Following spacecraft insertion to the target orbit, the Block DM-SL will separate from the spacecraft and perform a contamination and collision avoidance maneuver (CCAM). Disposal options include transfer of the Block DM-SL to a higher or lower disposal orbit or establishment of a low enough orbit to ensure re-entry. The final operation of the Block DM-SL will be to vent all volatile liquids and gasses to prevent explosive destruction.

A.5.3 Range Tracking Assets

The current Sea Launch baseline range tracking assets will be centered on the ACS. Other tracking assets include: a downrange tracking ship (the Selena-M) if deployed; a satellite system called Altair (also called Luch or Lutch); an American system called Tracking and Data Relay Satellite (TDRS), and the ground tracking stations in and around Russia, including the Moscow Center. Other assets continue to be considered. The following paragraphs (Sections A.5.4 to A.5.7) apply to launch vehicle telemetry reception and routing. Payload unit and satellite telemetry handling baselines have not been finalized.

During the ascent, the Zenit-3SL will be tracked by a combination of ships and satellites. For the first 410 sec the trajectory will be visible to the ACS, which is located five km from the launch platform. Throughout the remainder of the ascent to LEO park orbit, the trajectory will be visible to the Selena-M tracking ship if deployed 2,200 km downrange. The Russian Altair tracking and data relay satellite system will provide additional coverage for subsequent Block DM-SL burns beyond the range of these two ships.

A.5.4 Assembly and Command Ship

The launch sequence/countdown for the integrated launch vehicle (ILV) will begin several hours before launch and will be controlled remotely from the ACS. After the launch the ACS receives telemetry from the LV until the LV is acquired by TDRS and the Selena-M (if deployed).

A.5.5 Range Tracking Ship (Selena-M)

Launch vehicle telemetry will be received onboard the Selena-M (if deployed) until the Block DM-SL burn places the Block DM-SL, spacecraft, and related hardware into LEO parking orbit. This telemetry will be collected and re-transmitted via communication satellites to the mission control center (MCC) on the ACS and to the Moscow Center.

A.5.6 Satellite Tracking System

After orbital insertion, the Block DM-SL will continue to broadcast telemetry to the Altair satellite system. When the Block DM-SL is within line-of-sight of an Altair, it will broadcast telemetry to the Altair which will relay the telemetry (via communication satellites and ground stations) to the ACS and to the Moscow Center. When the Block DM-SL is not within line-of-sight of an Altair, it will store the telemetry and transmit the data after it comes within view.

A.5.7 Launch Location

Since the Zenit-3SL is launched from a mobile, sea-based launch platform, there is some flexibility in the location of the launch. However, considerations such as stage impact points, weather, and LP transit times restrict the vehicle from being launched at any location. Figure A.5.7-1 identifies the launch region in the Pacific Ocean. All data in this section assume an equatorial launch location with coordinates 0^0 N, 154^0 W. This is approximately 10 days LP sailing time from the Home Port, and less than one day ACS sailing time from Kiritimati (Christmas) Island.

A.5.8 Ascent Trajectory

The Zenit-3SL ascent trajectory will be tailored to optimize the mission's critical performance parameters while satisfying spacecraft and launch vehicle constraints. This section gives an overview of the ascent trajectory and flight profile.

Table A.5.1-1 (Section A.5.1) and Figures A.5.8-1 through A.5.8-3 illustrate a typical Zenit-3SL ascent trajectory for a GTO mission. Table A.5.1-1 is a listing of the times at which the main mission events occur, and Figure A.5.8-1 shows the ascent groundtrack and illustrates the tracking coverage. Figures A.5.8-2 and A.5.8-3 show the flight profile to GTO, with key events and parameters labeled.

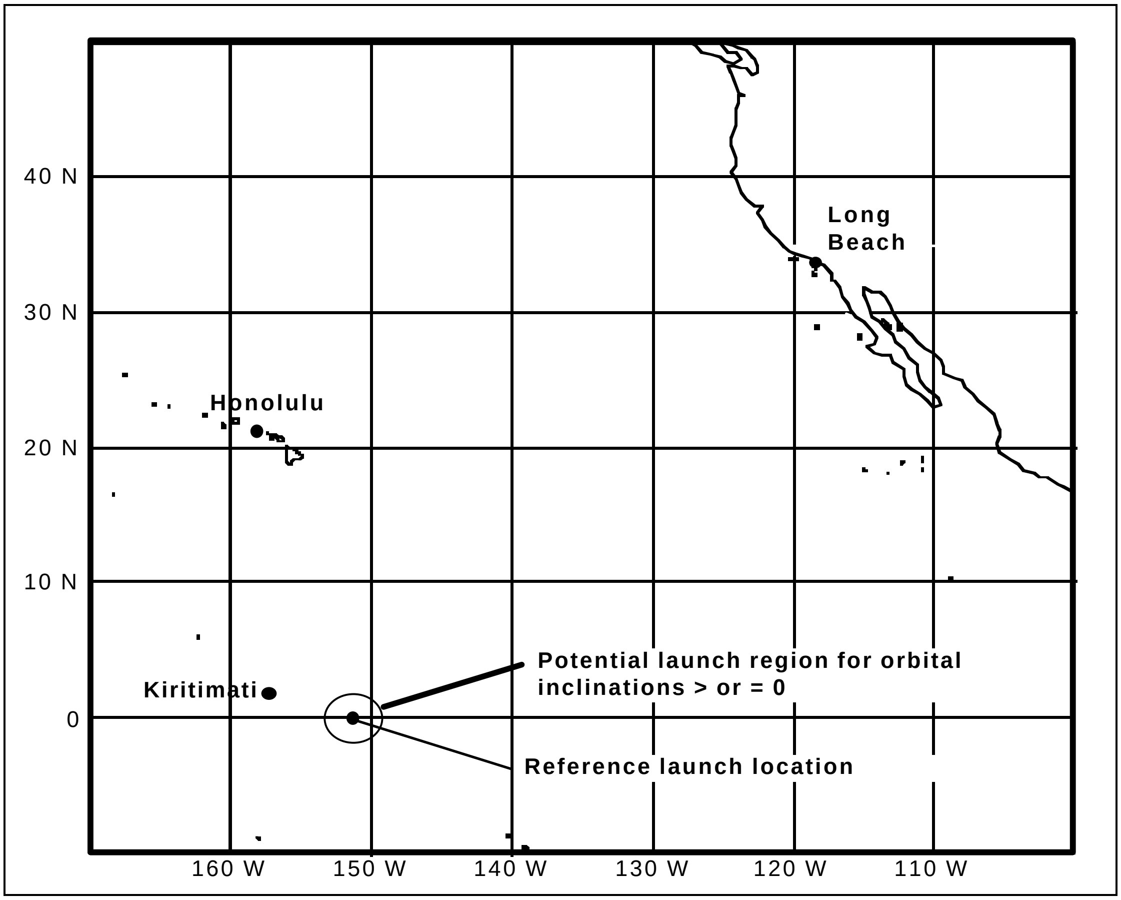


Figure A.5.7-1. Potential Launch Region

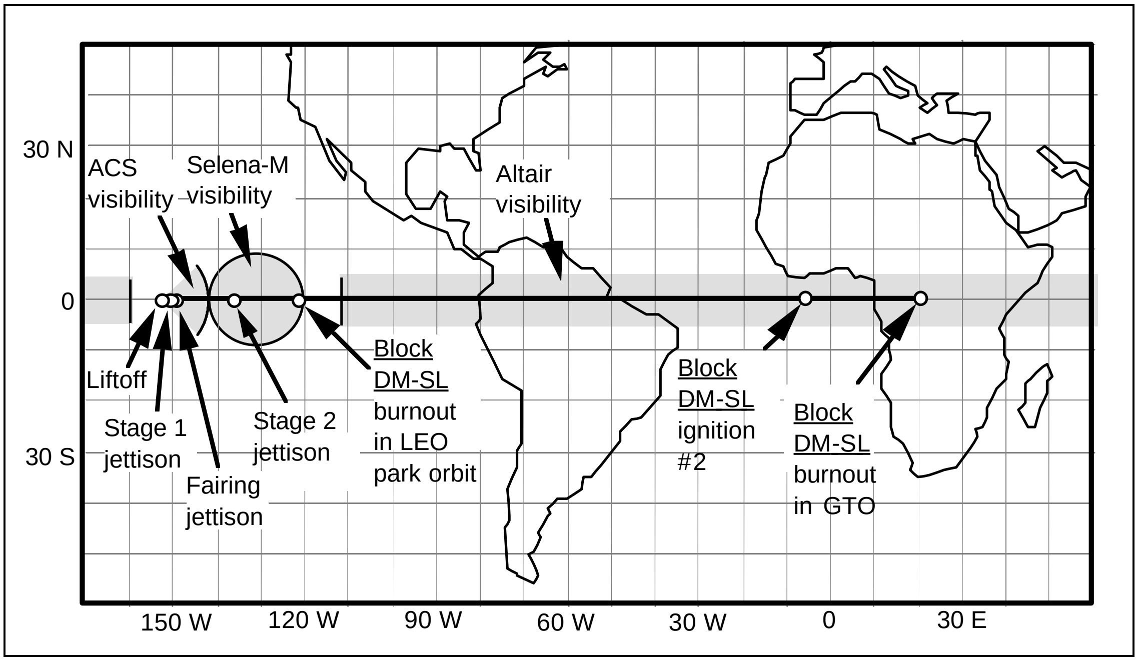


Figure A.5.8-1. Typical Flight Profile - GTO Mission

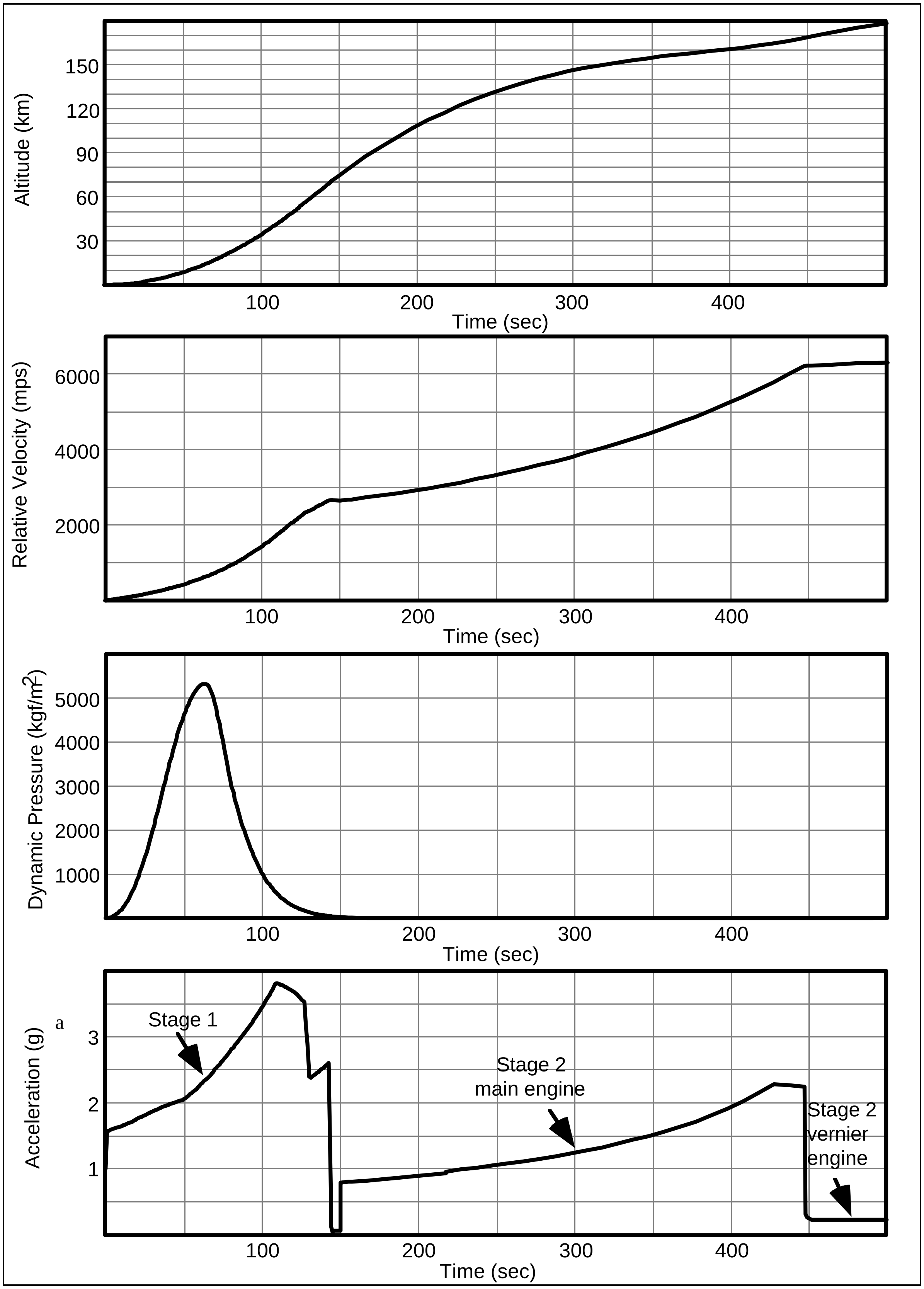


Figure A.5.8-2. Typical GTO Trajectory Parameters - Stage 1 and Stage 2

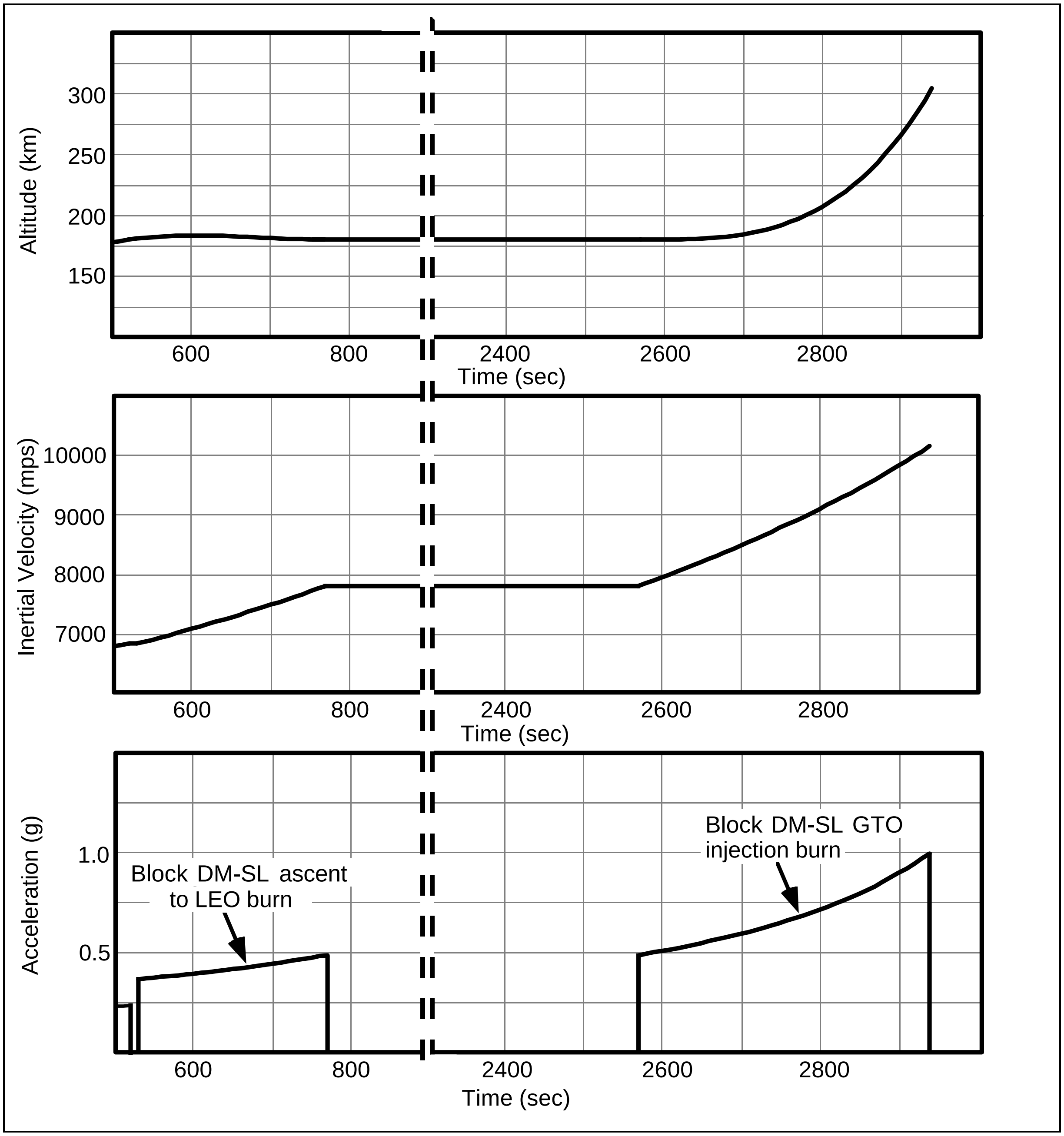


Figure A.5.8-3. Typical GTO Trajectory Parameters - Block DM-SL

APPENDIX B

PRINCIPAL HAZARDS ASSOCIATED WITH THE SEA LAUNCH PROGRAM

B. OVERVIEW

This appendix describes the hazards that may pose a threat to the public or the environment from Sea Launch operations. Hazards that Sea Launch systems or operating personnel may encounter that do not pose a threat to the public or the environment are not discussed. The following subsections are included: B.1 Home Port Assessment, B.2 Launch Site Assessment, B.3 Characteristics of Hazardous Materials, B.4 Hazardous Waste, B.5 General Industrial Waste, and B.6 List of Hazardous Materials.

The proposed Sea Launch Home Port is an industrial operation common with other daily industrial and commercial activities at the Port of Long Beach located in the Los Angeles area. The Port and City of Long Beach and State of California are highly experienced in regulating varied businesses, many of which are inherently much more hazardous than Sea Launch. Oversight will be provided by the local regulatory agencies responsible for ensuring safety at the Home Port.

The facilities at the Home Port have been specifically designed to minimize the potential for any accidents, and in the rare event of an accident, to minimize the potential impacts. It should be noted that there are no public areas on the Navy Mole. The open space located to the east of the Home Port is being used for the relocation of trees from the Navy Shipyard, supporting the Port of Long Beach in its efforts to obtain air quality credits. The Port of Long Beach has no plans to allow public access to this area. Industrial facilities do not currently operate on the Navy Mole. The Port of Long Beach intends to lease the adjoining property for use as a container storage area, which would be similar to the other container storage facilities in the Port of Long Beach.

Risks due to hazardous material spills, explosions, or other catastrophic events will be minimized by the design of the facilities and the required plans and permits for the operation of the Home Port. The facilities have been designed to meet several criteria. The Codes that were followed include: Uniform Building Code, Uniform Fire Code, National Electric Code, DOD Ammunition and Explosives Safety Standards, and Chemical Propulsion Information Agency (CPIA) guidance. In addition to meeting a variety of design criteria, operation of the Home Port will not occur until Sea Launch has prepared numerous plans which are required by Federal, state, and local regulations. These include, but are not limited to: Chemical Import Certification, Hazardous Materials Emergency Plan, Spill Prevention Control and Countermeasure Plan, Facility Response Plan, Operations Manual, Stormwater Pollution Prevention Plan, and Hazardous Materials/Dangerous Cargoes permit.

Under these plans, Sea Launch will develop designs (e.g., dikes, berms) to contain spills of petroleum and will outline responsibilities and perhaps conduct simulations to respond to catastrophic hazardous material or other events. Sea Launch will actively work with local emergency organizations (e.g., fire and police departments) to ensure these preparedness and response plans contain their input. Sea Launch has the benefit of designing the facility with safety in mind. Safety distance requirements for storage and handling of propellants were determined to be adequate to protect inhabited buildings and public traffic routes (Department of the Navy, 1996). Employees will be informed of work hazards and trained to follow proper operating procedures and to respond to anomalies. Response to spills into the port or navigable waterways and other environmental areas will be coordinated logistically and procedurally with Coast Guard and other proper authorities.

Although the results of a potential accident could be substantial, between the design of the facility and the plans and procedures that are required to be in place by regulations, it is anticipated that any impacts to public safety and the environment would be minor and mitigable.

Specialized facilities and equipment are being designed and will be constructed for the dedicated purpose of Sea Launch Home Port operations. A primary objective of the design and construction will be to ensure safety of not only Sea Launch employees, customers, and extremely high value equipment, but to safeguard the public, property, and the environment.

Sea Launch will provide new seagoing vessels which will be used to perform the final steps in the rocket assembly process. These vessels will contain unique features which will enable Sea Launch personnel to support launch vehicle assembly operations and ensure safe operations. Local port regulations, national and international maritime regulations, and design standards will be applied to in the design of the vessels and in the operations carried out onboard.

Sea Launch will provide a working marine facility where provisioning, storage, and fueling will be performed in support of the maritime operations. Existing buildings, the pier, driveways, and utilities will be upgraded for the dedicated functions performed on the vessels and through the use of its support equipment. Operations will be comparable to other marine terminal and industrial facility activities currently being performed in the port area.

Sea Launch will conduct a thorough and formal safety analysis of designs and operations prior to the start of testing or to the start of normal operations. This effort will be led by Boeing Commercial Space Company (BCSC) personnel, who have gained a high level of experience in the safety analysis process from years of work in the defense and aerospace industries. The Boeing Company's policies emphasize safety and environmental protection in all operations for commercial, non-commercial, and internal ventures. Sea Launch management stresses safety and environmental protection as a key issue throughout the program planning and development phases. The development structure used within Boeing and carried over to Sea Launch is to build in safety by identifying and mitigating potential hazards early in the preliminary design phase.

This safety analysis approach has several important benefits to Sea Launch:

1. Economy in lower rework costs and lower costs due to liabilities.
2. Efficiency due to improved delivery response and fewest interruptions.
3. Protection for employees, the public, public property, Sea Launch assets and investments, and the environment.
4. Prevention of fines and stop work orders by ensuring compliance with applicable regulations.

The Home Port will be located on the converted Long Beach Naval Base breakwater known as the "Mole." The property will be owned by the Port of Long Beach which has controls in place to limit public access. The facilities surrounding the Home Port consist of container cargo terminals, heavy industrial manufacturing plants, shipyards, oil drilling, and other comparable industrial and maritime activities. Considerable distances separate the Home Port property from non-industrial activities. The Queen Mary (the nearest tourist attraction) is 2.4 km away. The Interstate 710 freeway area is a major traffic artery feeding the port area and is over 1.6 km away at its closest point. Nearest urban development containing small businesses, residences, and major shopping centers is 3.2 km to 6.4 km away.

Home Port operations will mainly consist of the receipt, processing, and transferring of payload elements at the land-based facilities, and the receipt, processing, and transferring of rocket elements onboard the vessels at the pier. A new perimeter security fence will fully enclose and control access to Sea Launch property. The final spacecraft assembly, checkout, fueling, and encapsulation will take place in the newly constructed payload processing facility (PPF). The PPF is located inside a separate perimeter fence and provides a completely controlled environment for critical operations. The existing pier will be upgraded to provide moorage and utilities for the Sea Launch vessels. The basic structure of the pier will not be modified. A landing will be constructed to interface with the ACS stern ramp for roll-on/roll-off of cargo and rocket components.

Maritime operations will include pier side loading of supplies and equipment, vessel fueling (which will not occur at the Home Port), and transit between the Home Port and the launch location. At the launch location, the LP will be ballasted to a deeper draft to gain greater stability. The process of ballasting is not unique to Sea Launch and will present no hazard. The transfer of the launch vehicle on the vessels and movement of propellant from storage tanks to the launch vehicle requires appropriate shifting of water ballast to maintain the required vessel pitch and trim. Fueling of the launch vehicle will be accomplished after all personnel have been evacuated from the launch platform. The fueling system will be designed to preclude the release of RG-1 fuel (kerosene) into the environment during normal operations. The launch vehicle will be defueled in the event of a launch abort. During an abort, approximately 70 kg of RG-1 will be discharged into the water from the fuel lines. The propellant fueling system will be designed to retain all of the RG-1 fuel during the LV de-tanking operation. There will be some loss of oxygen due to boil-off during the tanking and de-tanking operations, but this loss will have no environmental impact or safety implications. Liquid nitrogen will be used to condition the fueling system and is converted to gaseous nitrogen to purge fueling system of vapors prior to disconnect of fueling fittings. This operation will prevent spillage of propellant components (kerosene and liquid oxygen) when disconnect occurs. During the purging process some kerosene vapors will be released into the environment.

B.1 HOME PORT ASSESSMENT

The detailed operations performed at the Home Port are summarized as follows:

1. The operations will begin with several warehouse and terminal type activities.

   a) Delivery of spacecraft and ground support equipment (GSE).

   b) Delivery of rocket stages.

   c) Delivery of flammable liquids.

   d) Delivery of compressed gases.

2. The use of crane and materials handling operations to place components in storage or processing as appropriate.

   a) Use of cranes to move payload and rocket elements in PPF and ACS.

   b) Use of dollies and trolleys to move rocket and fairing elements in warehouse.

c) Use of transport vehicles to move encapsulated payload between buildings and vessels.

d) Use of handling fixtures and stands to align and mate launch vehicle elements during final assembly.

3. Assembly and test steps involve systems checkout, final installations, and pressure tests of spacecraft and stages.

4. Cargo handling, terminal and bulk plant type operations, and transfer of components between vessels and land facilities.

    a) Loading of flammable liquids and compressed gases from transportable tanks to vessel tanks.

    b) Transfer of integrated launch vehicle from ACS to LP.

    c) Crane lifting of fairing containers from barge to pier or from truck to transport dolly.

5. Warehousing and shipping operations will involve unpacking and uncrating, receipt of maintenance supplies, materials storage, fairing container handling, and forklift and hoist operating.

B.1.1 Preliminary Hazard Analysis of Home Port Land-Based Operations

Preliminary hazard analysis of the Home Port operations began with the development of a list of high-level hazards that are based on materials and equipment involved in the operation. Four areas of concern were also determined for inclusion in the evaluation. They are as follows:

1. Public safety.
2. Sea Launch and customer personnel safety.
3. Damage to equipment or equipment safety.
4. Environmental protection.

The four principal hazards and general tasks identified which may have impacts on the public or the environment are:

1. Handling propellants for spacecraft and upper stage; transport and fueling with MMH, UDMH, and N_20_4.
2. Handling solid rocket motors and pyrotechnic devices; shipping and installation of SRMs, explosive bolts, pin pullers, cable cutters, and pyro-activated valves.
3. Loading launch vehicle gases and fuel on vessels; receipt and transfer of LOX, nitrogen, helium, and kerosene to bulk tanks onboard the LP and ACS.
4. Handling rocket stages and the assembled launch vehicle, crane lifts and wheeled dolly movements of fueled vehicle elements, and crane transfer of the assembled launch vehicle to LP.

In assessing potentially hazardous operations, all of the tasks contained in the operations were evaluated. Those that met the principal hazards criteria were grouped together in related generic operational categories. The categories of tasks identified as potentially hazardous are discussed in the following paragraphs.

It should be noted that all of the operations identified as potentially hazardous will be conducted in Sea Launch facilities which are uniquely designed to support the operation. The Navy "Mole" is designated as Port of Long Beach property, and public access to the location is limited. The Home Port site is fully fenced and patrolled by 24-hour security. Access to areas supporting hazardous operations will be strictly controlled.

B.1.1.1 Payload Processing Facility Operations

Four operations related to the processing of spacecraft at the payload processing facility have been identified as potentially hazardous due to the potential for a hazardous material release and employee exposure during a release. The major hazards involved in these operations are summarized here from detailed information and analyses prepared as part of Home Port permitting and licensing by Federal, state and local government agencies (Port of Long Beach Harbor Development Permit application):

1. Handling of flammable fuels and toxic oxidizers for spacecraft processing.
2. Handling of small pyrotechnics valves, pin pullers, and cable cutters during installation in the spacecraft and fairing.
3. Operating pressurized systems containing high pressure gas or toxic/flammable liquids onboard the spacecraft.
4. Crane handling of fueled spacecraft from the fueling stand, to the dolly, and to the encapsulation stand.

The potential impacts from these operations are:

1. Potential for major impact to Sea Launch and customer property from a very small amount of damage to high value assets and equipment.
2. Potential for major impact from injuries which could occur to Sea Launch and customer employees.
3. Minor impact to public safety or to the environment is anticipated due to the small quantities of hazardous materials present, and because the Home Port's location is relatively isolated from the general public.

The potential for major, adverse impact to Sea Launch employees, customers, and property from these operations is a driving force behind the design of the facilities and equipment described in the introduction of this section (Appendix B). Labor, building design and construction, and environmental regulations at the national, state, and local level must be satisfied before Sea Launch will develop and operate these facilities. Compliance with these regulations will aid in ensuring a safe environment in which to conduct Sea Launch operations, and will provide protection for the public and the environment.

B.1.1.2 Home Port Pier and Storage Facilities Operations

Operations related to materials handling operations at the pier, storage facilities, and throughout the Home Port site have been identified as potentially hazardous. The major hazards involved in these operations are:

1. Transfer of high pressure gasses and cryogenics from trucks to vessel bulk tanks, and the transfer of flammables and combustibles in transportable tanks to vessel storage areas and bulk tanks.
2. Handling of fueled and pressurized spacecraft from the PPF to the ACS via driveways and the stern ramp.
3. Transport of low explosive devices in shipping containers from delivery trucks and vessels to storage facilities and to vessel storage and assembly compartments.
4. The handling of unfueled rocket stages and support equipment via driveways, the stern ramp, and cranes from delivery vessels to storage facilities and to vessel assembly compartments.

The potential impacts from these operations are:

1. Potential for major impact to Sea Launch and customer property from a very small amount of damage to high value assets and equipment.
2. Potential for major impact from injuries which could occur to Sea Launch and vendor employees.
3. Minor impact to public safety or to the environment because of the small quantities of flammables and low explosives present and due to the isolation of the location.

B.1.1.3 Rocket Stages Processing

Major hazards involved in operations related to processing rocket stages and assembling the integrated launch vehicle onboard the ACS have been identified as follows:

1. Handling of combustible fuel, flammable fuel, and toxic oxidizer for upper stage processing.
2. Handling of low explosives devices and pyrotechnic devices during installation on stages.
3. Crane handling and moving rocket stages on wheeled dollies during processing and assembly.
4. Handling of fueled and pressurized spacecraft with the crane and wheeled dolly for alignment and mating to upper stage.

The potential impacts from these operations are:

1. Potential for major impact to Sea Launch and customer property from a very small amount of damage to high value assets and equipment.
2. Potential for major impact from injuries which could occur to Sea Launch employees.
3. Minor impact to public safety or to the environment due to the small quantities of flammables and low explosives present and due to the isolation of the location.

B.1.1.4 Integrated Launch Vehicle Transfer

One operation that has been identified as potentially hazardous is the transfer of the integrated launch vehicle from the ACS to the LP. The major hazard involved in this operation is in the crane handling of the integrated launch vehicle (consisting of the fueled spacecraft, partially fueled Block DM-SL, and unfueled rocket stages with solid rocket retro motors installed) during the transfer from the ACS stern ramp to the LP rocket hangar.

The potential impacts in the areas of concern are:

1. Minor impact to public safety or to the environment due to the small quantities of flammables and low explosives present and due to isolation of the location.
2. Potential for major impact from injuries which could occur to Sea Launch employees.
3. Potential for major impact to Sea Launch and customer property from a very small amount of damage to high value assets and equipment.

B.1.2 Regulatory Agencies and Regulations

The types of potentially hazardous operations (listed above) identify the areas that are being assessed in detail and will receive oversight in facility and equipment development. The regulatory environment in California provides oversight to this development with numerous controls on the Home Port development and operation. Tables B.1.2-1 through B.1.2-3 illustrate the four basic areas of concern (public safety, personnel safety, equipment safety, and environmental protection) and the regulatory focus for the previously identified operations. The table title contains the general description of the type of operations included. The matrix provides a general breakdown of regulatory agencies, and regulations related to each area of concern are shown for three levels of government.

The matrix can be used as a road map to show the application of regulations and agency oversight on identified potential hazards. It also serves as a preliminary “check-off” tool to verify compliance with the laws imposed on the Home Port design and operations.

B.1.2.1 U.S. Coast Guard

Because of the marine nature of the Home Port development, one of the most prominent agencies that Sea Launch will be working with is the U.S. Coast Guard. The U.S. Coast Guard has the charter to enforce the safety and security of ports and to enforce laws relating to the protection of the marine environment in the United States.

B.1.2.2 Federal Occupational Safety and Health Administration

The U.S. Department of Labor’s Occupational Safety and Health Administration (OSHA) is chartered to develop and promulgate occupational safety and a California agency is tasked with administering federal and the state’s OSHA regulations. While occupational safety is not specifically public safety, it is mentioned here because attention to occupational safety will be a contributing factor to public safety. For example, OSHA regulations address crane operations, hazardous material handling, and safety analysis of hazardous operations. Regulation of these occupational hazard areas will additionally reduce potential for adverse impacts to public safety and the environment.

B.1.2.3 Long Beach Department of Health and Human Services

The Department of Health and Human Services is chartered to protect the public from exposure and/or the adverse health effects of hazardous substances. Hazardous substance requirements are also a matter of concern for the California Department of Toxic Substances Control, the Long Beach Health Department, and the Long Beach Fire Department.

Table B.1.2-1. Receipt, Storage, and Transfer of Spacecraft and Upper Stage Fuel

Description, Hazard, Area of Concern	U.S. and International Agencies	State of California Agencies	Local Agencies
Public Safety	49 CFR, Transportation including: 171, General 177, Explosives 178, Packaging 32 CFR 650, Storage of Hazardous Materials 40 CFR 112, Oil Pollution 40 CFR 300-350, SARA	California Dept. of Toxic Substances Control, California State Office of Emergency Services	Long Beach Fire Dept., Risk Management and Prevention Program, Port of Long Beach, Tariff #4, Item 744, Rule on Dangerous and Hazardous Materials
Personnel Safety	29 CFR, Subtitle B, Chapter XVII, Occupational Safety and Health Administration, Section 119, Process safety management of highly hazardous chemicals	California Health and Safety Code, California Labor Code/ calico California Department of Health Services	
Equipment Safety	National Fire Protection Association 30, Chapter 4, Flammable and Combustible Liquids Code		City of Long Beach Dept. of Planning & Building
Environmental Protection	40 CFR, Protection of Environment, Environmental Protection Agency	California Environmental Protection Agency, California State Water Resource Control Board, Cal. Coastal Commission	Port of Long Beach, South Coast Air Quality Management District, Regional Water Quality Control Board

B.1.2.4 California Office of Emergency Management

The Office of Emergency Management is chartered to prevent or mitigate damage to human health and the environment. This requirement is promulgated through the Business Emergency Plan, which is submitted to and evaluated by the Long Beach Fire Department.

B.1.2.5 Long Beach Fire Department

The Long Beach Fire Department is responsible for the protection of life and property within the community. One of the major permits that Sea Launch must obtain is the Risk Management & Prevention Plan (RMPP). The RMPP includes an intensive system safety evaluation of the design of equipment, work practices, system reliability, and preventive maintenance procedures. It also includes risk assessment for specific equipment, emergency response planning, and the internal or external auditing procedures.

Table B.1.2-2. Transfer of LOX, Kerosene, Nitrogen, and Helium from Transport Trucks to LP Storage Tanks

Description, Hazard, Area of Concern	U.S. and International Agencies	State of California Agencies	Local Agencies
Public Safety	49 CFR, Transportation	California Dept. of Toxic Substances Control, California State Office of Emergency Services, California Harbor and Marina Code	Long Beach Fire Dept., Port of Long Beach, Tariff #4, Item 744, Rule on Dangerous and Hazardous Materials
Personnel Safety	29 CFR, Subtitle B, Chapter XVII, Occupational Safety and Health Administration	California Health and Safety Code, California Labor Code/ Calico, California Department of Health Services	
Equipment Safety	National Fire Protection Association 30, Chapter 4, Flammable and Combustible Liquids Code 49 CFR, Transportation	California Harbor and Marina Code	City of Long Beach Dept. of Planning & Building
Environmental Protection	40 CFR, Protection of Environment, Environmental Protection Agency	California Environmental Protection Agency, South Coast Air Quality Management District, California State Water Resource Control Board, Cal. Coastal Commission	Port of Long Beach, Regional Water Quality Control Board

Table B.1.2-3. Receipt, Storage, and Transfer to ACS of Solid Rocket Motors and Ordnance

Description, Hazard, Area of Concern	U.S. and International Agencies and Organizations	State of California Agencies	Local Agencies
Public Safety	27 CFR, Chapter 1, Part 55, Bureau of Alcohol, Tobacco, and Firearms, Commerce in Explosives 29 CFR, Subtitle B, Chapter XVII, Occupational Safety and Health Administration, Section 109 Explosives	California Health and Safety Code, Division 11	Long Beach Fire Dept. Port of Long Beach, Tariff #4, Item 744, Rule on Dangerous and Hazardous Materials
Personnel Safety	29 CFR, Subtitle B, Chapter XVII, Occupational Safety and Health Administration, Section 109 Explosives	California Health and Safety Code, California Labor Code/ Calico	Long Beach Fire Dept.
Equipment Safety	National Fire Protection Association 495, Explosive Materials Code, Chapter 6, Above Ground Storage of Explosive Materials		Long Beach Fire Dept. Port of Long Beach, Tariff #4, Item 744, Rule on Dangerous and Hazardous Materials
Environmental Protection		No Impact (unless fire or other event releases chemicals to the environment (see 40 CFR)	

B.2 LAUNCH LOCATION ASSESSMENT

B.2.1 Preliminary Hazard Assessment of Pre-Launch Operations

Pre-launch operations will take place at the launch location and involve positioning the vessels, doing final processing of launch vehicle and satellite hardware, and staging and preparing equipment on the vessels to enable the launch. These operations are described in paragraph 4.3.1 as part of the assessment of environmental impacts. Employee safety considerations are addressed in the Safety Risk Assessment which is part of the Sea Launch license application (SLLP Launch License Application D688-10121-1). The Safety Risk Assessment includes provisions for readiness reviews and rehearsals prior to each launch to demonstrate that the Sea Launch personnel, policies, and procedures meet or exceed all safety standards and requirements imposed by AST.

B.2.2 Preliminary Hazard Assessment of Launch/Flight Operations

Flight operations for Sea Launch will begin with the liftoff of the launch vehicle from the launch platform and continue until the spacecraft is separated and the Block DM-SL is placed in a safe disposal orbit. For a typical geosynchronous transfer orbit (GTO) mission, the total elapsed time until spacecraft separation is approximately 50 minutes, of which nearly 20 minutes is in a thrusting state. Upon reaching low earth orbit (LEO), approximately 13 minutes after liftoff, the potential for hazards affecting the earth are significantly reduced. Potential hazards resulting from flight operations can be grouped into two primary categories: normal operations and contingent operations. In each of these categories, hazards can also classified into two subsets: public safety and on-orbit safety.

B.2.2.1 Normal Operations

B.2.2.1.1 Public Safety

During normal flight of the launch vehicle, all operations prior to attainment of LEO occur over open ocean waters. An important parameter used to quantify hazard potential is the instantaneous impact point (IIP). The IIP is the location on the earth's surface where the launch vehicle would impact if the thrust were terminated. The IIP can be used to predict areas in which pieces of the rocket will impact the earth's surface at various times in the ascent trajectory. Additional effects, such as launch vehicle dispersions, atmospheric drag and winds, can also be applied to the IIP to give higher confidence to the regions in which returning debris is likely to fall. Because of the remote launch location, all planned pieces of debris normally returning to earth fall in open ocean waters.

Figure B.2.2-1 shows the ascent groundtrack and IIP as functions of time for a typical GTO mission. During staging operations prior to the attainment of LEO, the spent stages are jettisoned and return to earth under gravitational influence. Additionally, shortly after Stage 2 ignition, the protective fairing surrounding the spacecraft is also jettisoned for return to earth. A sleeve adapter surrounding the lower portions of the Block DM-SL is also jettisoned during Stage 2 separation. As shown in the figure, all planned pieces of debris return to earth over broad ocean waters. Shipping traffic routes indicate that the vessel density in the equatorial debris fall zones is among the lowest in the world. Since no debris impacts on populated areas, the risk to public safety from normal operations is negligible.

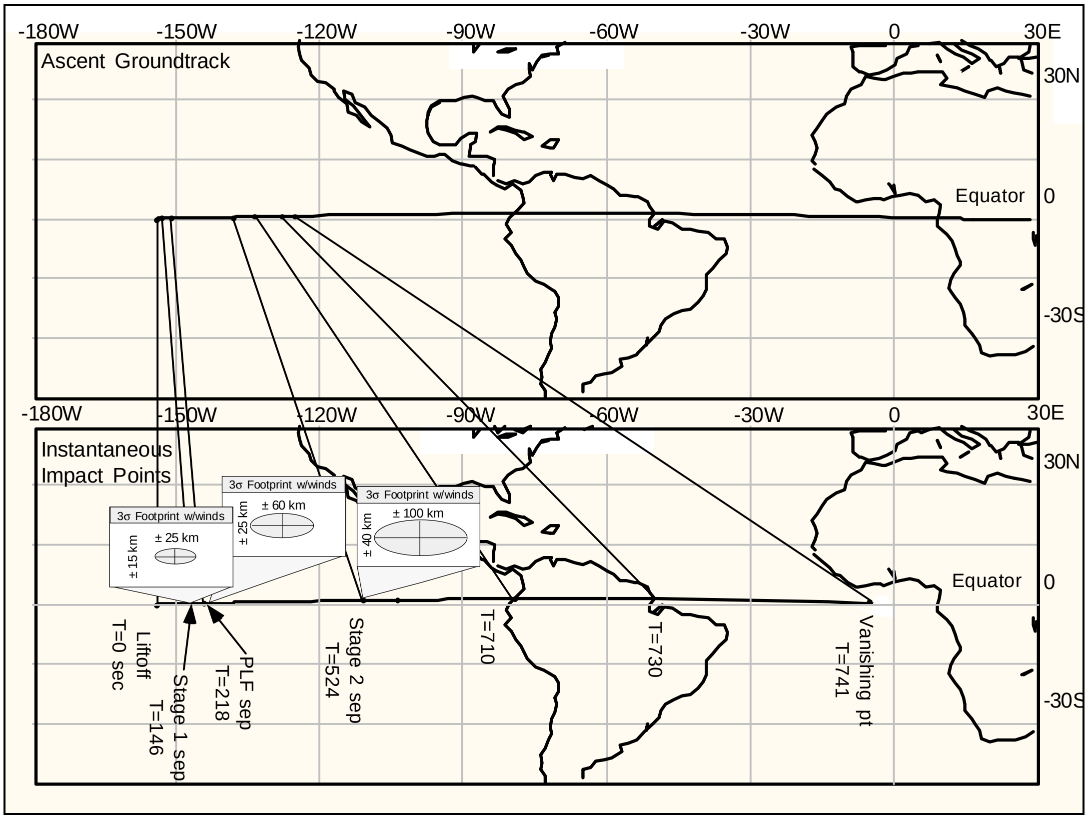


Figure B.2.2-1. Typical Ascent and Instantaneous Impact Point Groundtrack

B.2.2.1.2 On-Orbit Safety

After the vehicle reaches LEO, the primary hazards associated with the flight operations are related to the generation of orbital debris. This is most important during separation and after mission completion when the spent Block DM-SL is left in a disposal orbit. During separation, there is the potential for the generation of orbital debris from pyrotechnic bolts or releasing mechanisms. Sea Launch requires that no orbital debris be generated during spacecraft separation, thus mitigating the hazard risk of orbital debris generation from separation bolts or debris. For long-term storage of spent upper stages, Sea Launch has adopted NASA document NSS 1740.14 ("Guidance and Assessment Procedures for Limiting Orbital Debris," August, 1995) as a program goal for mitigating the risk of on-orbit debris. This NASA document defines characteristics for both normal and contingent operations. One of the critical parameters for normal operations is the spent upper stage final disposal orbit. Figure B.2.2-2 shows the acceptable regions for circular disposal orbits. For transfer orbits, the projected life until atmospheric reentry should not exceed 25 years. Shortly after successful spacecraft separation, the Block DM-SL vents all propellants and gases. This procedure mitigates potential problems associated with previous Block DM ullage motor tanks exploding while in the post-mission storage orbit and provides for a safe storage configuration.

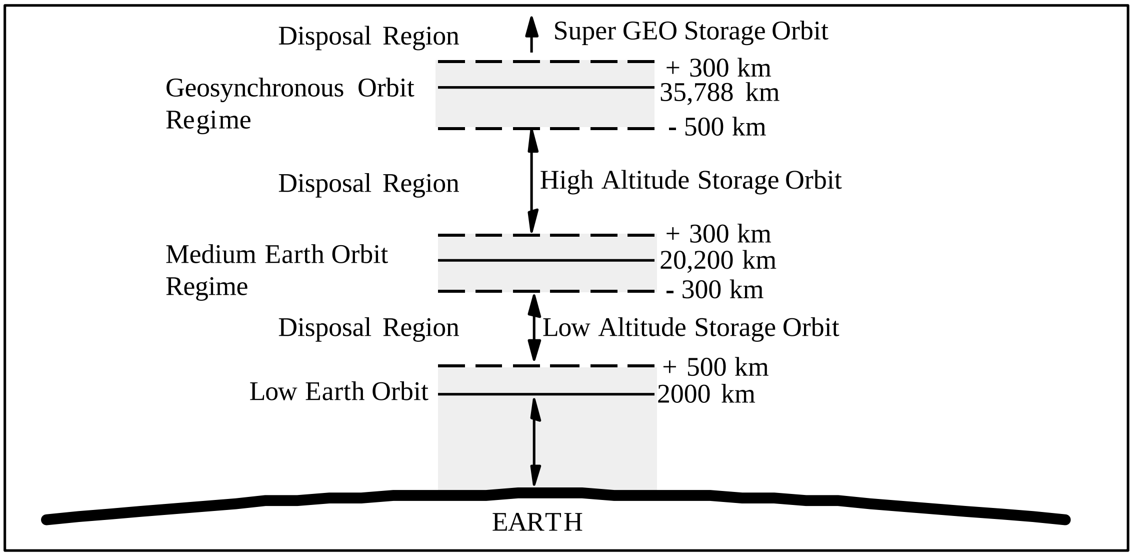


Figure B.2.2-2. Circular Disposal Orbit Regimes for Spent Stages

B.2.2.2 Contingent Operations

B.2.2.2.1 Public Safety

Contingent operations include the various failure modes that cause the vehicle to operate in an unsafe or unplanned trajectory. Such operations include, but are not limited to, rocket motor failures, explosions, control system failures, and electronic system failures. Since the launch occurs in remote ocean waters, the vast majority of the IIP dwell time is spent over ocean waters. Because of this fact, the flight hazards that potentially affect the general public are reduced. In order to assess the hazard risk during IIP passage over populated areas of South America, a quantifiable measure of risk must be used. One such measure of safety commonly used is the casualty expectation, which is the probability of a fatality due to flight operations. A typical level of safety for rocket launches is one casualty for each one million launches. This casualty value has been adopted as the Sea Launch objective for overall flight safety based on its functional equivalence to the values used at U.S. Government launch ranges. A comparison between Sea Launch and traditional functions performed by the U.S. at the Eastern Test Range (ETR) (Cape Canaveral) and the Western Test Range (WTR) (Vandenberg) was considered (SSLP, 1997).

Sea Launch safety assurance will be primarily obtained through proper analysis, testing, mission planning, and design of the Zenit flight safety system, and is described fully in the Sea Launch System Safety Plan. Determination of the casualty expectation is a function of the system failure rate, impact debris size, population density, and the time the IIP remains over populated areas (i.e., dwell time). For a typical GTO mission, the casualty expectation is considerably less than the one in a million safety objective (SSLP, 1997).

To ensure safe launch vehicle operations in the event of a flight contingency, the Zenit-3SL will incorporate an autonomous flight safety system (FSS) that reduces the hazard risk presented to the public. The FSS will use the Zenit-3SL flight control computers to monitor both computer health and status and mission performance. In the event of a failure in the computer or in the overall launch system, a thrust termination system will be activated that terminates engine thrust. In order to assess the flight computer health and status, three processors will be used in a voting scheme to filter out anomalous signals or failed processors. If the computer determines it is operating without sufficient redundancy, it will issue a command to terminate the launch vehicle thrust. Flight performance verification will be accomplished by comparing the actual launch vehicle flight angles with preplanned flight angles. Whenever the actual angles exceed predetermined tolerance limits, the flight computer will terminate main engine thrust, preventing errant rocket trajectories. Figure B.2.2-3 illustrates these angles for a typical GTO mission. By conducting computer simulations of a wide variety of failures at various times in the ascent trajectory, impact limit lines (ILL) can be determined for the purposes of determining where debris could fall. A statistical confidence level, such as three standard deviations, is commonly used to quantify the dispersions that could cause the debris to fall within this flight corridor if a catastrophic failure were to occur. The ILLs include dispersions in launch vehicle guidance, navigation and control systems, as well as atmospheric wind effects.

Through the combination of a remote launch location and the autonomous FSS, hazards to the public will be minimized and kept well within acceptable levels.

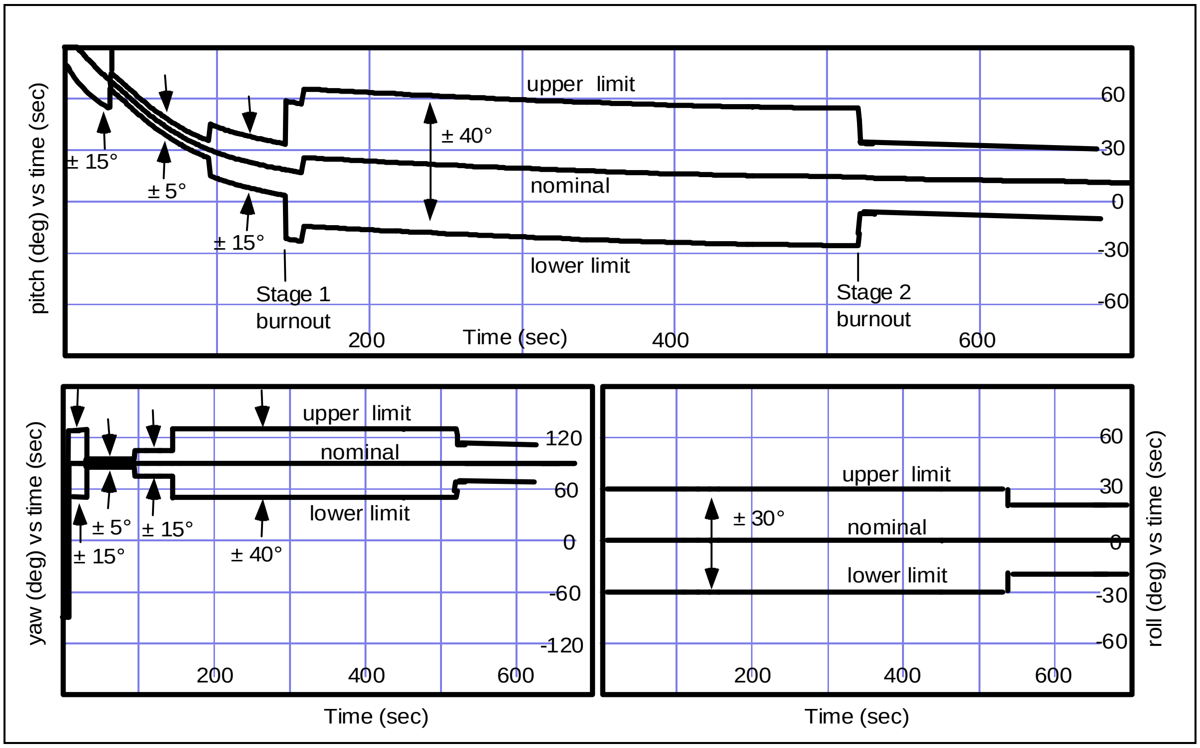


Figure B.2.2-3. Flight Safety Angle Limits

B.2.2.2.2 On-Orbit Safety

Once in orbit, potential hazards to other spacecraft will occur if a flight contingency occurs. As discussed in Section 5, paragraph 5.2.4, contingent flight operations will result in two primary failure modes. The first is when an in-flight fire or explosion destroys the Block DM-SL and spacecraft, dispersing fragments in orbit. This failure mode is more hazardous for on-orbit safety, since a potentially large number of pieces propagate through space, creating the potential for orbital collisions with viable spacecraft. In the second failure mode, the FSS system terminates thrust and separates the spacecraft prior to its intended orbit. This failure mode is desirable because the Block DM-SL vents all gasses and propellants and remains intact in orbit. Additionally, the spacecraft is also separated, thus providing for potential mission salvage through the spacecraft onboard systems.

B.2.3 Preliminary Hazard Assessment of Post-Launch Operations

Post-launch operations begin with the re-boarding of the Launch Platform following the launch. LP marine systems and launch equipment will be checked and stabilized, and the LP will be prepared for the return sail to the Home Port. A detailed procedure and hazard assessment for this process remains under development. This information will be available in Operations Document No. OD-SLP-LP-07, "Launch Platform Securing and Entry" and the supporting Hazard Assessment documentation.

B.3 CHARACTERISTICS OF HAZARDOUS MATERIAL

The principal hazardous material handled at Sea Launch facilities are the chemicals used in the propulsion systems of the integrated launch vehicle. These include liquids, solids, and ordnance used to operate propulsion system valves, to operate each stage of the rocket, and to operate the spacecraft (see Table B.3-1 for a listing of ILV hazardous materials). Ordnance is also used to initiate spacecraft appendage deployment after launch.

Table B.3-1. Summary of Integrated Launch Vehicle Hazardous Material

Rocket Vehicle	Approximate Mass In Tons
1. Propellant mass loaded on Stage 1:	325 tons
a. Liquid oxygen	235 tons
b. RP-1 fuel	90 tons
c. Starting fuel (butyl) mass first stage	4.25 kg
2. Propellant mass loaded on Stage 2:	81.5 tons
a. Liquid oxygen	58.5 tons
b. RP-1 fuel	23 tons
3. Upper stage, Block DM-SL:	
a. Main propellant mass loaded	15000 kg
b. Liquid oxygen	11000 kg
c. RP-1 fuel	4400 kg
d. Propellant mass loaded in the auxiliary propulsion system & main engine starting fuel	
(1) Nitrogen tetroxide	44 kg
(2) Unsymmetrical dimetylhydrazine	74 kg
(3) Nitrogen (pressurization)	2 kg
(4) Starting fuel (mixture of triethylaluminum and trimethylaluminum)	2 kg
Data On Pyrotechnics	**Quantity of Hardware**
1. Stage 1:	
a. Solid rocket retromotors (21.1 kg propellant each) within the separation system	4
b. Pyrotechnic valve in the propellant system	1
c. Pyrotechnic valves in the pressurization system (helium supply from submerged high pressure vessels)	5
2. Stage 2:	
a. Solid rocket retromotors (5.25 kg propellant mass each) in the stage separation system	4

b. Explosive bolts for separation from Stage 1	10
3. Upper stage (Block DM-SL):	
a. Explosive bolts for separation from Stage 2	10
b. Explosive bolts for sleeve separation	8

Liquid fuels and oxidizers will be used as propellants. The spacecraft will be primarily fueled with monomethyl hydrazine (MMH); however, some spacecraft will use anhydrous hydrazine (AH). The oxidizer used by the spacecraft is primarily nitrogen tetroxide (N_2O_4). These components are handled at ambient conditions without elevated pressures or reduced temperatures. They are volatile and, when in contact with one another, will spontaneously ignite, liberating extremely large quantities of heat and gas (hypergolic). A particular spacecraft may require only fuel (i.e., monopropellant system) or both fuel and oxidizer (i.e., bipropellant system).

The upper stage (Block DM-SL) attitude control/ullage propulsion engines use unsymmetrical dimethylhydrazine (UDMH) and N_2O_4. The characteristics of UDMH are typical of the hydrazine family. The two stages of the Zenit and the main engine of the upper stage use kerosene (RG-1) for fuel and liquid oxygen as the oxidizer. The upper stage fuel is loaded prior to mating with the Zenit second stage. The remaining fuel and oxidizer are loaded during pre-launch processing at the launch location after personnel have evacuated the launch platform.

The following quantity of material represents the maximum expected for any launch:

1. Spacecraft propellant for a typical spacecraft.

   a) Monomethylhydrazine - 680 kg (1,500 lb)

   b) Nitrogen tetroxide - 1,043 kg (2,300 lb)

2. Upper stage (Block DM). To provide backup, the total quantity on location may be twice this amount.

   a) UDMH - 44 kg

   b) N_2O_4 - 74 kg

Note: The propellant quantities listed in Section 4, table 4.2.2-1, are different because they are mission specific.

The major hazard from these propellants result from their flammability and reactivity characteristics. These propellants have properties similar to other hazardous chemicals, which are routinely transported throughout the U.S. on the nation’s highways, and are manufactured and used in a variety of industrial operations. Hydrazine is a key ingredient in a variety of agrochemicals, including many common pesticides, fungicides, algaecides, bactericides, and herbicides.

Hydrazines are volatile chemicals that react readily with carbon dioxide and oxygen in the air and will also decompose some metals on contact. Hydrazine is slightly less dense than water; the vapors are more dense than air. If hydrazine vapor is released into the air in sufficient concentrations, it may ignite or react to form ammonia and oxides of nitrogen. Further oxidation will form ammonia-based nutrients and will ultimately return to earth as nitric acid rains.

Hydazines are also corrosive, poisonous, and can present serious health hazards upon direct contact with sufficient quantities of either the liquid or vapor. The most severe exposures occur through dermal (i.e., skin) contact with liquid and inhalation. Contact of the chemical on the skin can cause severe burns and can enter the bloodstream, leading to similar effects caused by inhalation. These effects may include damage to the central nervous system which can result in tremors, convulsions, or death in the case of extremely high concentrations of the chemical. According to the American Council of Industrial and Government Hygienists, hydrazine is also a suspected human carcinogen.

Nitrogen tetroxide is a thick, heavy, and very volatile liquid. Its vapor pressure is about 50 times that of water and about five times that of acetone. Though not flammable itself, N_2O_4 enhances the combustion of most fuel sources and may ignite organic materials. Nitrogen tetroxide reacts with water in a vigorous reaction that produces nitric and nitrous acids and NO_2. Contact with corrosive N_2O_4 liquid or vapor may lead to burns of the skin and eyes. Inhalation of a sufficient quantity of N_2O_4 vapor causes adverse health effects and may initially occur without great discomfort. A few hours later, however, more severe symptoms of tightness in the chest, coughing, and breathing difficulty may begin and could result in pulmonary edema, and in severe cases, death.

The principal environmental and personnel protection method employed is through system design. A principle of zero planned release of hydrazine into the environment has been incorporated in the design of the systems and development of procedures used for their processing. The potential for accidental release has been assessed and appropriate containment for the operating area and scrubber systems is being incorporated into the facilities design.

Procedures have been written that will help safeguard and instruct the operating personnel. These procedures define proper sequencing of critical events, provide detailed instruction where required, define use of personnel protection equipment, define the establishment of controlled areas, and define the limitation of access to essential personnel in potentially hazardous operating areas.

Waste containment and neutralization systems serve the fuel and oxidizer propellant operating areas. All propellant vapors released in processing areas will be processed through these systems. Tanks collect any liquid spillage which could occur during propellant transfer operations.

The greatest hazard during operations with these components is the potential of mixing hypergolic materials. The principal defense for this potential hazard is to separate components. Separate storage areas and processing systems have been incorporated into the design of both the PPF and the ACS. The principal operational control is in processing one component at a time and in complete cleanup following that operation prior to starting the next operation.

The potential for an explosive environment developing in the hydrazine processing area has been considered and the design requirements for these areas have been incorporated. The PPF is designed per the National Electric Code, Section 70, of the National Fire Protection Association Codes. The ACS Block DM-SL fueling compartment is designed per Det Norske Veritas, Rules for Classification of Ships. Static grounds are provided for fueling equipment, and adherence to written procedures ensure proper connection during operations.

The danger of a tank leaking toxic material during handling is mitigated by compliance to 49 CFR Parts 171-180, as summarized in the Hazardous Materials Table at 49 CFR 172.101. DOT approved tanks for hypergolic fuels and oxidizers are used for transportation, temporary storage of spacecraft, and upper stage hazardous fuel components.

Exhaust gas composition for N_2O_4 and hydrazine[1] is as follows:

1. CO - 0.03561
2. CO_2 - 0.09563
3. H - 0.00006
4. H_2 - 0.04969
5. H_2O - 0.45886
6. OH_x - 0.00003
7. N_2 - 0.36012

The primary hazard from solid propellant in the SRMs processed in Sea Launch facilities is due to its flammability. Solid propellant is classified by the DOD as a Class 2, Division 1.3 (non-mass - detonation, mass-fire hazard). (Reference DOD Directive 6055.9, DOD Ammunition and Explosives Safety Standard, July 1984). The material itself is not explosive; however, a solid propellant produces large volumes of gas when burning, which can result in the rupture or propulsion of the case.

The solid propellant used in the Zenit separation motors is a nitrocellulose base with less than 10% nitrogen. This chemical composition relates to a hazard class of flammable solid, DOT Class 1.4. Because the packaging of the chemical is in a motor case, it is considered a DOT Class 1.3.

1. Zenit first stage: four solid rocket retromotors (21.1 kg propellant each) within the separation system.
2. Zenit second stage: four solid rocket retromotors (5.25 kg propellant mass each) in the stage separation system.

Exhaust gas composition for the SRM exhaust plume is as follows:

1. CO - 0.3858
2. H_2O - 0.1411
3. H_2 - 0.2045
4. N_2 - 0.1171
5. CO_2 - 0.1506
6. Pb - 0.0009

Liquid oxygen is not an environmental hazard. The volume of liquid oxygen required to support a launch cycle is 500 metric tonnes.

The significant hazards related to operations involving liquid oxygen are:

1. Oxygen enriched atmosphere supports accelerated combustion of fuels.

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[1] AIAA Workshop Report dated 1 October 1991, Atmospheric Effects of Chemical Rocket Propulsion, Table 8.

2. Extreme low temperature. The systems used to handle cryogens will be designed and operated in accordance with industry standards.

The combination of kerosene and liquid oxygen has been used as a propellant system in launch vehicles by most countries since space programs started. This use of liquid oxygen/kerosene has resulted in vehicle reliability, an acceptable safety record, and efficient launch operations. Its good performance and high density is well suited for the minimum-size launch vehicle. The ease of handling and ambient storage temperatures of kerosene make it suitable for a shipboard-based launch system. Safety requirements for handling kerosene onboard a ship are similar to those of handling diesel fuel.

The emissions from liquid oxygen and kerosene have minimal effect on the environment. Exhaust product composition for LOX and kerosene are:

1. CO - 0.35954
2. CO_2 - 0.14479
3. H_2 - 0.26265
4. H_2O - 0.23301

As the exhaust is discharged into the atmosphere, afterburning will occur, modifying the mole fractions and introducing some new compounds (i.e., NO_x) which are eventually released in the atmosphere. Quantitative data on the products generated by afterburning as a function of altitude are not available.

Nitrogen is not a hazardous substance and will not, under normal conditions, pose a threat to the public. For each launch cycle, 240 metric tonnes of liquid nitrogen is loaded onboard the LP and 10 metric tonnes of gaseous nitrogen is loaded on the ACS.

It may be a public hazard under the following conditions:

1. Release of nitrogen gas in an enclosed space may result in an oxygen deficient environment that will not support life. This condition is addressed in the design of the ACS and LP. Oxygen monitors have been included in spaces that could potentially contain an oxygen deficient atmosphere.
2. Operating procedures and instructions will include provisions to ensure access control of confined spaces as required by existing regulations.
3. The extreme low temperature of liquid nitrogen is a hazard. The systems used to handle cryogens will be designed and operated in accordance with industry standards.

Ordnance devices employed are defined as electroexplosive devices, detonators, squibs, primer, pyrotechnic devices, solid rocket motors, and energy transfer systems. The hazards produced by ordnance are the potential for ignition or detonation.

Ordnance items being transported to Sea Launch facilities from within the U.S. will be examined in accordance with CFR 49, Part 173.56, by the Association of American Railroads, Bureau of Explosives or U.S. Department of Interior, Bureau of Mines, and assigned a recommended shipping description and hazard classification. Ordnance items will be approved for transportation by the U.S. Department of Transportation. For ordnance items originating outside of the U.S., the Associate Administrator for Hazardous Materials Safety acceptance of an approval, issued by the competent authority of the country of origin as listed by the International Maritime Dangerous Goods (IMDG) Code, will be required.

Written acknowledgment of acceptance must be received before shipment. Copies of the acknowledgment and of the competent authority approval must accompany each shipment.

Both the ACS and LP are built in accordance with the International Convention for the Prevention of Pollution from Ships (MARPOL 73/78) to control the discharge of oil into the environment. There is no greater risk to the environment from Sea Launch vessels than from any other ship. The following is the estimated usage of fuels for each round trip between the Home Port and proposed launch location:

1.	Diesel oil -	ACS	1,350 m^3;
		LP	1,450 m^3
2.	Lube oil -	ACS	6 m^3;
		LP	8 m^3

Helium gas is not a hazardous substance and will not, under normal conditions, pose a threat to the public. It may be a public hazard when a large volume is released in an enclosed or confined space resulting in an oxygen deficient environment. The approximate amount of gaseous helium loaded on the LP (at 400 kgf/cm^2 pressure) in support of each launch cycle is 0.9 metric tonnes; the ACS is 0.5 metric tonnes.

B.4 HAZARDOUS WASTE

The hydrazine and nitrogen tetroxide processing system design will minimize the generation of hazardous waste. Excess hydrazine and nitrogen tetroxide remaining after an operation will be returned to the manufacturer for recycling. Spillage of any hydrazine and nitrogen tetroxide will be neutralized in the collection tanks and properly disposed of. Other hazardous materials used during launch vehicle assembly, conducted at the Home Port and onboard ships, will generate a minimum amount of waste. The materials used include cleaning agents/solvents and various adhesives. The following is a generic list of typical items:

1. Acetone.
2. Ethyl alcohol.
3. Gasoline.
4. Isopropyl alcohol.
5. Lacquers.
6. Polyamide resins.
7. Lubricants.

B.5 GENERAL INDUSTRIAL WASTE

B.5.1 Home Port Facility Non-Hazardous Waste

The Home Port is expected to generate a relatively limited amount of nonhazardous waste similar in quantity to that required to support the maintenance and operations of a small office complex. Nonhazardous waste will be removed from the site by a locally contracted waste management company. Site wastes will be managed according to their source and characteristics and options for recycling and reuse. Plans coordinated with local officials as noted will address as appropriate the separation of hazardous from nonhazardous wastes, waste collection, training and instructions for employees, and planning for process changes and their associated wastes.

B.5.2 Shipboard Waste

Approximately 100 liters of diesel or kerosene is used per month onboard each vessel for general cleaning of machinery. Approximately four liters of Electro-clean (white spirit) is used per month onboard each vessel for general cleaning of electrical equipment.

Waste products onboard the ACS will be collected in containers and burned in the ship's incinerator during the voyage or transferred to the Home Port for disposal/recycling.

Bilge water is normally separated onboard each vessel during the voyage. However, arrangements have to be provided for transferring the bilge water ashore during long stays in the Home Port. The ACS is provided with a bilge water tank of 160 m^3, and the LP has a tank of 30 m^3.

Sewage/gray water will be discharged to publicly-owned treatment works via the Home Port shore facilities while in port. During sea operations, the sewage treatment plant on the ACS and LP will handle sewage/gray water in compliance with Annex IV, Regulations for the Prevention of Pollution by Sewage of the International Convention for the Prevention of Pollution from Ships (MARPOL 73/78).

Oil sludge will be separated onboard each vessel. Onboard the ACS, waste oil products will be burned in the ship's incinerator during the voyage. In port, shore connections for delivery of oil sludge will be provided for each ship.

Garbage will be handled during the voyage in accordance with Annex V, Regulations for the Prevention of Pollution by Garbage of MARPOL 73/78. Garbage suitable for burning will be burned in the ACS incinerator during the voyage. Other garbage onboard the ACS and all garbage onboard the LP will be collected in containers and transferred ashore when in port.

B.6 LIST OF HAZARDOUS MATERIALS

Table B.6-1 provides a listing of hazardous materials identified to date. Any hazardous waste generated during spacecraft and launch vehicle processing will be controlled in accordance with EPA hazardous waste regulations and transported in accordance with DOT regulations. The table contains a preliminary listing of hazardous material and the approximate quantity used during processing of each launch vehicle. Data on the documents listed for reference have been provided by the Sea Launch Limited Partnership.

Table B.6-1. List of Process Hazardous Materials (Preliminary)

Material	Approximate Quantity Used Per Launch	References, Remarks
Acetone	1.5 L (B-DM) 0.5 kg (Zenit)	GOST 260-79
Adhesives (various)	1.22 kg (B-DM)	
Diethyleneglycolurethane	0.02 kg (B-DM)	
Ethyl alcohol	6.0 L (B-DM) 20 kg (Zenit)	GOST 5962-67 Highly flammable fluid. Rate 3
Gasoline	2.0 L (B-DM)	Highly flammable fluid. Rate 3
Isopropyl alcohol	TBD	Highly flammable fluid. Rate 3
Lacquer	0.5 kg (B-DM)	Highly flammable fluid. Rate 3

Material	Approximate Quantity Used Per Launch	References, Remarks
Lubricants	0.6 kg (B-DM)	Highly flammable fluid. Rate 3
Methyl ethyl ketone	TBD	Highly flammable fluid. Rate 3
Paints	2 kg (B-DM)	Highly flammable fluid. Rate 3
White spirit	1 kg (Zenit)	GOST 313-18. Highly flammable fluid. Rate 3
Cold carrier "Chladon-113"	30 kg (Zenit)	GOST 23844-79. Non-flammable, low toxic fluid. Rate of hazard defined by PEL in working zone per GOST 12.1.007-79. Rate 4 (PC 3000 mg/m)
Nefras-S3-80/120	1 kg (Zenit)	GOST 443-76. Highly flammable fluid. Rate 3
Working fluid "L3-MG-2"	14 kg (Zenit)	TY-38.10128-81 Highly flammable fluid. Rate 3
Hermetic paste "VGO-1"	4 kg (Zenit)	TY 38.303-04-04-08 GOST 12.1.004-85 Group IV Flammable product.
Hermetic paste "YG-5M2"	4 kg (Zenit)	TY-6-01-2-670-88 Highly flammable fluid. Rate 3
Glue "BF-4"	0.1 kg (Zenit)	GOST 12172-74 Highly flammable fluid. Rate 3
Glue "88-CA"	0.5 kg (Zenit)	TY 38-105760-87 Highly flammable fluid. Rate 3
Glue "88-NP"	0.5 kg (Zenit)	TU 38.105540-73 Highly flammable fluid. Rate 3
Glue NT-150	0.5 kg (Zenit)	TY-38.105789-75 Highly flammable fluid. Rate 3
Glue "VK-9" consisting of: a. Resin "ED-20" b. Resin "PO-300" c. Product "AMG-3" d. Product "ADZ-3" e. Titanium dioxide	(Zenit) 0.3 kg 0.2 kg 0.0029 kg 0.001 kg 0.025 kg	GOST 92-0949-74. GOST 10587-84, Moderately dangerous substance Rate 9 TY 6-10-1108-76 Highly flammable fluid. Rate 3 Highly flammable fluid. Rate 3 Fire & explosive safe material. Rate of hazard defined by PC in working zone per GOST 12.1.007-79. Rate 4 (PC 3000 gm/m)
Glue "K-300-61" consisting of: a. Resin "SEDM-6" b. Polyamide resin "L-020" c. Titanium dioxide	(Zenit) 0.6 kg 0.24 kg 0.18 kg	GOST 92-0949-74 GOST 6-05-5125-82, Fire & explosive safe material. TY 6-05-1123-73, Fire & explosive safe material. Fire & explosive safe material. Rate of hazard defined by PC in working zone per GOST 12.1.007-79. Rate 4 (PC 3000 gm/m)
Nitroglue	0.2 kg (Zenit)	TY 6-10-1293-78, Highly flammable fluid. Rate 3

Notes:
1. This list provides an indication of the launch process potential impact. Industrial materials used to operate and maintain the vessels and maintain the Home Port facilities have not been identified.
2. The launch operations supported by the vessels and Home Port facilities includes the assembly of manufactured components, but does not include manufacturing processes that use hazardous chemicals or metals.

APPENDIX C

PARTNERSHIP DESCRIPTION

C. PROJECT ORGANIZATION AND PARTNER RESPONSIBILITIES

The entity responsible for environmental concerns on the Sea Launch Program is the Sea Launch Limited Partnership (SLLP) acting through its General Partner, the Sea Launch Limited Duration Company (LDC). Both the SLLP and the Sea Launch LDC are organized under the laws of the Cayman Islands, B.W. I. The SLLP is responsible for the development work and for entering into launch contracts with customers and performing those contracts. The address and telephone number of the Sea Launch Limited Partnership, the Sea Launch LDC, and the Launch Platform Limited Partnership are:

Sea Launch Company, LDC
Strandveien 37
1324 Lysaker, Norway
N-1324

phone: 9-011-47-67-526350

fax : 9-011-47-67-526399

There are four companies involved in this venture:

1. Boeing Commercial Space Company
2. Kværner Maritime a.s
3. KB Yuzhnoye
4. RSC Energia

The LDC is the General Partner of the SLLP and will perform under The Company Law (Revised) of the Cayman Islands. The LDC will issue contracts with the Partners for the development work on behalf of the SLLP.

The principal responsibilities of each company are illustrated in Figure C-1. A short description of each company's responsibility follows this introductory section.

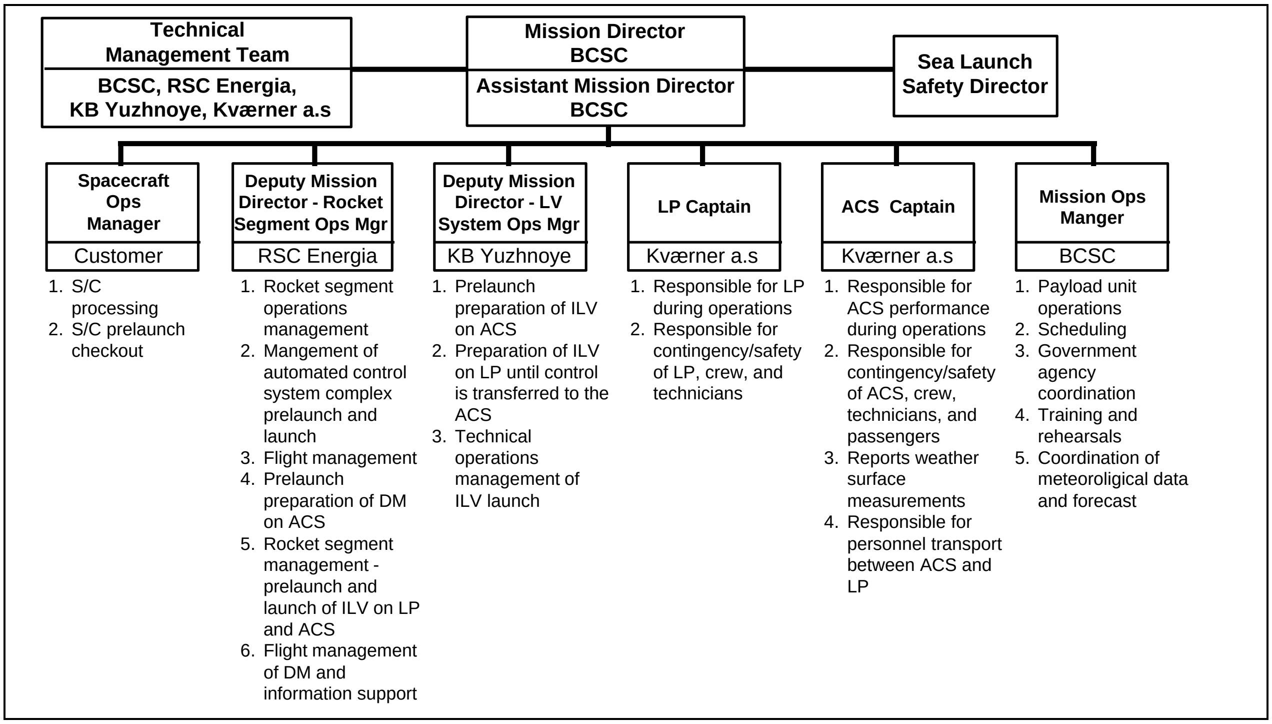

Figure C-1. Mission Operations Team

All launches will be licensed through the Associate Administrator for Commercial Space Transportation (AST), within the Department of Transportation's (DOT) Federal Aviation Administration (FAA). Sea Launch is marketing its services to United States and international spacecraft manufacturers. The Sea Launch payloads will be communication, navigation, or remote sensing satellites. Payloads will be licensed by appropriate U.S. agencies and/or foreign countries. Registration of space objects is required by United Nations, Article IV of 1975 Convention on Registration of Objects Launched into Outer Space. The process Sea Launch has established for payload registration begins 60 days before launch with notification to AST. Thirty days before launch, Sea Launch will notify U.S. Space Command (USSC), 1st Command and Control Squadron, Combat Analysis Code J30XY, of the initial orbit parameters, points of contact, launch vehicle description, launch vehicle size, and description of object(s) to be orbited. On launch day, USSC will be notified that the launch has occurred. Within 30 days of the launch, AST will be provided with the international designator, date and location of launch, orbital parameters, and general function of the space object(s). For U.S.-owned payloads, AST transfers this information to the State Department, which notifies the United Nations within five months. Registration of an object owned by a foreign entity is the responsibility of that foreign entity.

C.1 BOEING COMMERCIAL SPACE COMPANY

Boeing Commercial Space Company (BCSC) has the responsibility for project management, will submit the launch license application data package to AST, and will plan the missions and interface with the customer and/or spacecraft manufacturer. In addition, BCSC will develop and manufacture the payload fairing (PLF), the payload adapter (PLA), and will develop the Home Port (HP). The development of the HP includes environmental analysis sufficient to satisfy all government jurisdictions (i.e., California governmental agencies, the City of Long Beach, the Port of Long Beach, local fire departments, and the U.S. Coast Guard). Also, BCSC will operate the HP and market the Sea Launch Venture. During the operational phase, BCSC will lead the Mission Operations Team.

C.2 KVÆRNER MARITIME A.S

Kværner Maritime a.s is constructing the assembly & command ship (ACS), refurbishing the launch platform (LP), and will manage all maritime activities including all environmental analysis for maritime activities. During operational phase, Kværner will contract to operate the ACS and the LP.

The ACS Limited Partnership has entered into a contract with Kværner for building the ACS and for providing the ship to the LDC. In addition, it is responsible for related maritime planning, licensing, and operations.

The LP Limited Partnership has entered into a contract with Kværner for building the LP, providing the vessel to the LDC, and providing planning, licensing, and operations related to the LP.

C.3 KB YUZHNOYE

KB Yuzhnoye will modify and manufacture the Zenit's first and second stage hardware and software in order to meet new requirements levied by Sea Launch customers. During the operational phase, Yuzhnoye will support launch activities associated with the Zenit and associated Zenit ground support equipment. In particular, Yuzhnoye will support the pre-launch preparation of the integrated launch vehicle (ILV) on the ACS and the preparation of the ILV on the LP until control is transferred to the ACS during the countdown phase.

C.4 RSC ENERGIA

RSC Energia is modifying and manufacturing the Block DM-SL upper stage hardware and software in order to meet new requirements levied by Sea Launch customers. In addition, Energia will install all launch vehicle vessel support equipment. During the operational phase, Energia will support launch activities and in particular will:

1. Manage the rocket segment operations.
2. Manage the automated control system complex during pre-launch and launch.
3. Manage the flight segment.
4. Execute the pre-launch preparation of the Block DM-SL on the AC.
5. Manage the rocket segment pre-launch and launch activities onboard the LP and ACS.
6. Manage the information support function during the flight of the Block DM-SL.
7. Manage the range assets including the ground stations in Russia.

APPENDIX D

GLOSSARY AND UNIT CONVERSION TABLE

D.1 GLOSSARY

Accretion	Gradual buildup of land or seafloor formed by magma rising to the surface along some tectonic plate boundaries.
Anaerobic	Absence of oxygen.
Annelids	Multi-segmented, worm-like animals.
ascent groundtrack	The projection, on the surface of the earth, of the launch vehicle flight path from liftoff until orbit insertion.
Benthic	Pertaining to or found at or on the sediment-water interface of a large body of water.
Biomass	The dry weight of living matter present in a species or ecosystem population for a given habitat area or volume.
boundary layer	The lowest portion of the atmosphere where the frictional effects of the earth's surface are substantial.
Coriolis force	Inertial momentum causing deflection of a moving object relative to the earth's surface; objects moving north and south of the equator are deflected to the right and left respectively.
demersal	Living at or near the bottom of the sea.
echinoderms	Demersal marine organisms with an internal skeleton and a system for flushing water through the body to permit movement, respiration, nourishment, and perception.
ecosystem	A conceptual view describing the interrelationships, including the flow of materials and energy, between living and non-living features of a natural community.
exclusive economic zone	An offshore boundary, usually set at 320 km, establishing a nation's economic sovereignty over the resources present within that perimeter.
food chain	Scheme for describing feeding relationships by trophic levels among the members of a biological community.
habitat	The physical environment in which a plant or animal lives.

instantaneous impact point	The impact point, following thrust termination of a launch vehicle, calculated in the absence of atmospheric drag effects (vacuum).
ionosphere	That part of the earth's upper atmosphere which is ionized by solar ultraviolet radiation so that the concentration of free electrons affects the propagation of radio waves.
mass balance	The accounting of all energy and/or matter that is in flux between or stable within subdivisions of a physical process or ecosystem.
mesosphere	That part of the earth's atmosphere above the stratosphere characterized by a temperature that generally decreases with altitude.
ozone	A form of oxygen, O_3, naturally found in the ozonosphere within the stratosphere.
phytoplankton	Passively floating or weakly self-propelled aquatic plant life.
primary productivity	New organic matter produced by plant life.
stratosphere	That part of the earth's atmosphere between the troposphere and the mesosphere in which the temperature increases with altitude.
tectonics	Movement and deformation of the earth's surface caused by fluid circulation beneath the surface.
thermosphere	That part of the earth's atmosphere extending from the top of the mesosphere to outer space, including the exosphere and ionosphere, marked by more or less steadily increasing temperatures with altitude.
trophic level	A broad grouping of organisms within an ecosystem defined as being in the same tier in the food chain hierarchy; most generally, the first trophic level is the photosynthetic plants, the second is the herbivores, and the third is the carnivores.
troposphere	That part of the atmosphere extending from the earth's surface to an altitude of 10 to 20 km, in which the temperature generally decreases with altitude.
upwelling	The process by which water rises from a deeper to a shallower depth; may be caused by a variety of physical phenomena.
zooplankton	Passively floating or weakly self-propelled aquatic animal life.

D.2 UNIT CONVERSION TABLE

Length

1 km (kilometer)	=	0.621 mile
1 m (meter)	=	3.28 feet
1 cm (centimeter)	=	0.394 inch
1 mm (millimeter)	=	0.0394 inch
1 µm (micron)	=	0.0000394 inch

Mass

1 kg (kilogram)	=	2.20 pounds
1 g (gram)	=	0.0353 ounce
1 mg (milligram)	=	0.0000353 ounce

Energy

1 J (joule)	=	0.239 calories

Velocity

1 km/second	=	2,240 miles/h
1 m/second	=	2.24 miles/h

Force

1 N (Newton)	=	0.225 pound (force)
1 kgf (kilogram force)	=	2.205 pound (force)

Volume

1 L (liter)	=	0.26 gallon

Probability (example)

1 in 1 million	=	$1x10^{-6}$
Degree of Latitude	=	Each 15^0 of latitude represents approximately 1,034 miles